

# PATENT ABSTRACTS OF JAPAN

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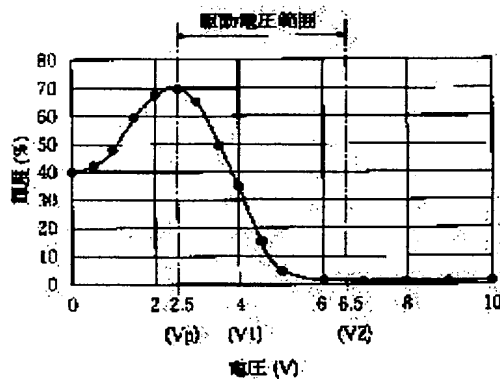
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(54) LIQUID CRYSTAL DISPLAY DEVICE AND DRIVING METHOD THEREFOR

(57)Abstract:

PROBLEM TO BE SOLVED: To provide a liquid crystal device enabling a display brighter than hereto fore without causing any gray scale inversion.

SOLUTION: In this liquid crystal display device of a scattering mode, when a direction of observation is set to a direction different from an exit direction of the light emitted forward from a liquid crystal layer in a transmission state of the liquid crystal layer, and the light is observed from the direction of observation, the device is provided with such a voltage-brightness characteristic as a brightness level rises once from its initial level up to reach a peak value and then ascends to almost zero level as an impression voltage ascends from zero V. Then the voltage range between a voltage value  $V_p$  at which the brightness level in this brightness-voltage characteristic takes a peak value and a voltage value  $V_2$  at which the brightness level takes almost 0 level is adopted as a



driving voltage range.

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## [Claim(s)]

[Claim 1] In the liquid crystal display in the dispersion mode which displays by changing a liquid crystal layer to a dispersion condition and a transparency condition The electrical-potential-difference value from which it has the brightness-voltage characteristic to which peak value exists in an intensity level in the process of the dispersion condition of a liquid crystal layer, and a transparency condition, and the intensity level in said brightness-voltage characteristic serves as peak value when it observes from [ predetermined ] observation, The liquid crystal display characterized by making into the driver voltage range the range of the electrical-potential-difference value from which an intensity level turns into abbreviation 0 level.

[Claim 2] In the liquid crystal display in the dispersion mode which displays by changing a liquid crystal layer to a dispersion condition and a transparency condition It is the normally white from which said dispersion mode serves as light status display in the state of dispersion at the time of no electrical-potential-difference impressing. When it observes from [ predetermined ] observation, take for applied voltage to rise from 0V, and an intensity level once rises from an init level, and reaches peak value. It is the liquid crystal display characterized by making into the driver voltage range the range of the electrical-potential-difference value from which it has after that an electrical-potential-difference-brightness property which descends up to abbreviation 0 level, and the intensity level in said brightness-voltage characteristic serves as peak value, and the electrical-potential-difference value from which an intensity level turns into abbreviation 0 level.

[Claim 3] In the liquid crystal display in the dispersion mode which displays by changing a liquid crystal layer to a dispersion condition and a transparency condition It is the normally black from which said dispersion mode serves as a dark status display in the state of transparency at the time of no electrical-potential-difference impressing. When it observes from [ predetermined ] observation, brightness is abbreviation 0 level until applied voltage reaches threshold voltage from 0V. If applied voltage exceeds threshold voltage, will take to the rise of applied voltage, and an intensity level rises, and peak value is reached. It is the liquid crystal display characterized by making the range of said threshold voltage value to which it has the descending electrical-potential-difference-brightness property after that, and the intensity level in said brightness-voltage characteristic begins to change from 0 level, and the electrical-potential-difference value from which an intensity level serves as peak value into the driver voltage range.

[Claim 4] The liquid crystal display according to claim 2 characterized by making into the driver voltage range the range of the highest electrical-potential-difference value and the electrical-potential-difference value from which said intensity level turns into abbreviation 0 level among the electrical-potential-difference values from which two or more peak value of the intensity level in said brightness-voltage characteristic exists, and turns into each peak value.

[Claim 5] The liquid crystal display according to claim 3 with which two or more peak value of the intensity level in said brightness-voltage characteristic exists, and said intensity level is characterized by making the range of the lowest electrical-potential-difference value into the driver voltage range among said threshold voltage value which begins to change from 0 level, and the electrical-potential-difference value from which it becomes said each peak value.

[Claim 6] The liquid crystal display according to claim 1 with which said observation direction is characterized by being set to a front side in the direction of outgoing radiation of the light by which outgoing radiation is carried out, and the different direction from a liquid crystal layer in the transparency condition of a liquid crystal layer.

[Claim 7] The liquid crystal display according to claim 2 with which said observation direction is characterized by being set to a front side in the direction of outgoing radiation of the light by which outgoing radiation is carried out, and the different direction from a liquid crystal layer in the transparency condition of a liquid crystal layer.

[Claim 8] The liquid crystal display according to claim 3 with which said observation direction is

characterized by being set to a front side in the direction of outgoing radiation of the light by which outgoing radiation is carried out, and the different direction from a liquid crystal layer in the transparency condition of a liquid crystal layer.

[Claim 9] The liquid crystal display according to claim 2 characterized by carrying out a bias drive.

[Claim 10] The liquid crystal display according to claim 3 characterized by carrying out a bias drive.

[Claim 11] The liquid crystal display according to claim 9 characterized by being constituted so that the bias voltage in said bias drive can be adjusted.

[Claim 12] The liquid crystal display according to claim 10 characterized by being constituted so that the bias voltage in said bias drive can be adjusted.

[Claim 13] The liquid crystal display according to claim 1 characterized by having a driver voltage adjustment means to adjust so that driver voltage may become said driver voltage range, according to change of said brightness-voltage characteristic.

[Claim 14] The liquid crystal display according to claim 2 characterized by having a driver voltage adjustment means to adjust so that driver voltage may become said driver voltage range, according to change of said brightness-voltage characteristic.

[Claim 15] The liquid crystal display according to claim 3 characterized by having a driver voltage adjustment means to adjust so that driver voltage may become said driver voltage range, according to change of said brightness-voltage characteristic.

[Claim 16] Said driver voltage adjustment means is a liquid crystal display according to claim 13 characterized by being constituted so that driver voltage may be adjusted according to the above-mentioned detection result, while having a detection means to detect the electrical potential difference corresponding to the peak value of said intensity level mostly.

[Claim 17] Said driver voltage adjustment means is a liquid crystal display according to claim 14 characterized by being constituted so that driver voltage may be adjusted according to the above-mentioned detection result, while having a detection means to detect the electrical potential difference corresponding to the peak value of said intensity level mostly.

[Claim 18] Said driver voltage adjustment means is a liquid crystal display according to claim 15 characterized by being constituted so that driver voltage may be adjusted according to the above-mentioned detection result, while having a detection means to detect the electrical potential difference corresponding to the peak value of said intensity level mostly.

[Claim 19] The above-mentioned driver voltage adjustment means is a liquid crystal display according to claim 13 characterized by being constituted so that driver voltage may be adjusted according to the above-mentioned detection result, while having a detection means to detect the temperature of the busy condition of a liquid crystal display.

[Claim 20] The above-mentioned driver voltage adjustment means is a liquid crystal display according to claim 14 characterized by being constituted so that driver voltage may be adjusted according to the above-mentioned detection result, while having a detection means to detect the temperature of the busy condition of a liquid crystal display.

[Claim 21] The above-mentioned driver voltage adjustment means is a liquid crystal display according to claim 15 characterized by being constituted so that driver voltage may be adjusted according to the above-mentioned detection result, while having a detection means to detect the temperature of the busy condition of a liquid crystal display.

[Claim 22] The liquid crystal display according to claim 1 with which the reflecting plate which makes it reflect and carries out outgoing radiation of the light which carries out incidence from the front side of said liquid crystal layer to a front side is characterized by preparing for the back side of said liquid crystal layer.

[Claim 23] The liquid crystal display according to claim 2 with which the reflecting plate which makes it reflect and carries out outgoing radiation of the light which carries out incidence from the front side of said liquid crystal layer to a front side is characterized by preparing for the back side of said liquid crystal layer.

[Claim 24] The liquid crystal display according to claim 3 with which the reflecting plate which makes it reflect and carries out outgoing radiation of the light which carries out incidence from the front side of said liquid crystal layer to a front side is characterized by preparing for the back side of said liquid crystal layer.

[Claim 25] The liquid crystal display according to claim 1 characterized by equipping the back side of said liquid crystal layer with the light source, and for the light of the direction of slant from the light source passing a liquid crystal layer, and carrying out outgoing radiation to a front side.

[Claim 26] The liquid crystal display according to claim 2 characterized by equipping the back side of said

liquid crystal layer with the light source, and for the light of the direction of slant from the light source passing a liquid crystal layer, and carrying out outgoing radiation to a front side.

[Claim 27] The liquid crystal display according to claim 3 characterized by equipping the back side of said liquid crystal layer with the light source, and for the light of the direction of slant from the light source passing a liquid crystal layer, and carrying out outgoing radiation to a front side.

[Claim 28] The liquid crystal display according to claim 1 characterized by displaying by active-matrix drive.

[Claim 29] The liquid crystal display according to claim 2 characterized by displaying by active-matrix drive.

[Claim 30] The liquid crystal display according to claim 3 characterized by displaying by active-matrix drive.

[Claim 31] The liquid crystal display according to claim 1 characterized by displaying by passive-matrix drive.

[Claim 32] The liquid crystal display according to claim 2 characterized by displaying by passive-matrix drive.

[Claim 33] The liquid crystal display according to claim 3 characterized by displaying by passive-matrix drive.

[Claim 34] The drive approach of the liquid crystal display characterized by carrying out a bias drive in the drive approach of the liquid crystal display in the dispersion mode which displays by changing a liquid crystal layer to a dispersion condition and a transparency condition.

[Claim 35] The drive approach of the liquid crystal display according to claim 34 characterized by performing the active drive by the active component array.

[Claim 36] The drive approach of a liquid crystal display according to claim 34 that said bias drive is characterized by being an opposite reversal drive.

[Claim 37] The drive approach of a liquid crystal display according to claim 34 that said bias drive is characterized by being a floating-gate drive.

[Claim 38] The drive approach of a liquid crystal display according to claim 34 that said bias drive is characterized by being a capacity-coupling drive.

[Claim 39] The drive approach of the liquid crystal display according to claim 34 characterized by the bias voltage in said bias drive being adjustable.

[Claim 40] The liquid crystal display characterized by having the brightness-voltage characteristic to which an intensity level with applied voltage higher than the intensity level in 0V exists in the process of the dispersion condition of a liquid crystal layer, and a transparency condition in the liquid crystal display in the dispersion mode which displays by changing a liquid crystal layer to a dispersion condition and a transparency condition when it observes from [ predetermined ] observation.

[Claim 41] The liquid crystal display according to claim 40 characterized by making into the driver voltage range the range to an electrical-potential-difference value in said brightness-voltage characteristic where an intensity level carries out monotone reduction, and turns into abbreviation 0 level from the electrical-potential-difference value from which said applied voltage serves as an intensity level higher than the intensity level in 0V.

[Claim 42] The liquid crystal display according to claim 40 characterized by being constituted so that said applied voltage which changes according to the service temperature of a liquid crystal display may become [ an intensity level higher than the intensity level in 0V ] the highest at service temperature within the limits.

[Claim 43] The liquid crystal display according to claim 40 characterized by being constituted so that the intensity level with said applied voltage higher than the intensity level in 0V which changes according to the service temperature of a liquid crystal display may become the highest in a room temperature mostly.

[Claim 44] The liquid crystal display according to claim 40 with which liquid crystal phase-isotropic phase transition temperature in the liquid crystal ingredient which constitutes said liquid crystal layer is characterized by being higher than the upper limit of the operating temperature limits of a liquid crystal display 20 degrees C or more.

[Claim 45] The liquid crystal display according to claim 40 with which liquid crystal phase-isotropic phase transition temperature in the liquid crystal ingredient which constitutes said liquid crystal layer is characterized by being 80 degrees C or more.

[Claim 46] The liquid crystal display according to claim 1 characterized by being constituted so that the peak value of said intensity level which changes according to the service temperature of a liquid crystal display may become the highest at service temperature within the limits.

[Claim 47] The liquid crystal display according to claim 1 characterized by being constituted so that the

peak value of said intensity level which changes according to the service temperature of a liquid crystal display may become the highest in a room temperature mostly.

[Claim 48] The liquid crystal display according to claim 1 with which liquid crystal phase-isotropic phase transition temperature in the liquid crystal ingredient which constitutes said liquid crystal layer is characterized by being higher than the upper limit of the operating temperature limits of a liquid crystal display 20 degrees C or more.

[Claim 49] The liquid crystal display according to claim 1 with which liquid crystal phase-isotropic phase transition temperature in the liquid crystal ingredient which constitutes said liquid crystal layer is characterized by being 80 degrees C or more.

[Claim 50] the case where dispersion gain of  $d$  (micrometer) and said liquid crystal layer is set to  $SG$  for the thickness of said liquid crystal layer --  $50\exp(-0.4d)$  --  $< SG < 360\exp(-0.47d)$

The liquid crystal display according to claim 1 characterized by \*\*\*\*\*.

[Claim 51] the case where the birefringence anisotropy of a liquid crystal ingredient [ in  $\Delta$ , for the dispersion gain of  $d$  (micrometer) and said liquid crystal layer / in the thickness of said liquid crystal layer /  $SG$  and said liquid crystal layer ] is set to  $\Delta n$  --  $50\exp(-1.6\Delta n-d)$  --  $< SG < 360\exp(-1.88\Delta n-d)$

The liquid crystal display according to claim 1 characterized by \*\*\*\*\*.

[Claim 52] The liquid crystal display according to claim 1 with which dispersion gain of said liquid crystal layer is characterized by being 10 or more and 200 or less.

[Claim 53] The liquid crystal display according to claim 1 with which dispersion gain of said liquid crystal layer of service temperature within the limits of a liquid crystal display is characterized by being 10 or more and 200 or less.

#### [Detailed Description of the Invention]

[0001]

[Field of the Invention] This invention relates to the liquid crystal display in the dispersion mode which displays by changing a liquid crystal layer to a dispersion condition and a transparency condition.

[0002]

[Description of the Prior Art] As a typical conventional example of the liquid crystal display in this kind of dispersion mode, the liquid crystal display of the transparency mold which carries out incidence of the slanting light, the reflective mold liquid crystal display using a reflecting plate, etc. are known. In such a conventional example, since the brightness in an early dispersion condition was decided, there was a problem that a bright display was not obtained. Moreover, in the liquid crystal display in the dispersion mode of the conventional example, when a halftone display was performed, there was a problem that tone reversal arose.

[0003]

[Problem(s) to be Solved by the Invention] However, the above-mentioned trouble was not essential in the dispersion mold liquid crystal display, and it became clear by this invention person's experimental result that it originated in the error having been in recognition of the brightness-voltage characteristic rather. That is, it was thought that the maximum level of the above [ brightness ] up to the range where brightness is the maximum level at the time of no electrical-potential-difference impressing as the brightness [ in this case ]-voltage characteristic is generally shown in drawing 23, when the case of a normally white is mentioned as an example, for example, and 0V to an electrical potential difference rises slightly at the time of electrical-potential-difference impression was maintained, the intensity level fell rapidly by the power surge after it, and abbreviation 0 level was reached. However, according to this invention person's experimental result, it became clear that an actual electrical-potential-difference-brightness property was not the property shown in drawing 23 but a property that peak value exists in an intensity level by electrical-potential-difference impression as shown in drawing 3. Therefore, with the liquid crystal display in the dispersion mode of the conventional example, since it was displaying based on a different electrical-potential-difference-brightness property from an actual electrical-potential-difference-brightness property, sufficient brightness is not obtained and it is thought that tone reversal had arisen. Then, this invention person came to invent the liquid crystal display which can solve the above-mentioned technical problem by displaying based on the electrical-potential-difference-brightness property shown in drawing 3.

[0004] this invention is markedly boiled compared with the conventional example, and a bright display is possible and it aims at offer of the liquid crystal display which can display without tone reversal arising.

[0005]

[Means for Solving the Problem] In order to attain the above-mentioned purpose, invention of claim 1 In the liquid crystal display in the dispersion mode which displays by changing a liquid crystal layer to a dispersion condition and a transparency condition The electrical-potential-difference value from which it has the brightness-voltage characteristic to which peak value exists in an intensity level in the process of the dispersion condition of a liquid crystal layer, and a transparency condition, and the intensity level in said brightness-voltage characteristic serves as peak value when it observes from [ predetermined ] observation, It is characterized by making into the driver voltage range the range of the electrical-potential-difference value from which an intensity level turns into abbreviation 0 level. According to the above-mentioned configuration, since peak brightness exists in the brightness-voltage characteristic, compared with the driver voltage range, then the conventional example, high brightness, i.e., a bright display, becomes possible about the range of the electrical-potential-difference value used as this peak brightness, and the electrical-potential-difference value from which brightness serves as 0% of abbreviation. Moreover, the tone reversal resulting from peak brightness not existing in the brightness-voltage characteristic and peak brightness existing in the brightness-voltage characteristic like the conventional example can be prevented by making the above-mentioned range into the driver voltage range. Moreover, invention of claim 2 is set to the liquid crystal display in the dispersion mode which displays by changing a liquid crystal layer to a dispersion condition and a transparency condition. It is the normally white from which said dispersion mode serves as light status display in the state of dispersion at the time of no electrical-potential-difference impressing. When it observes from [ predetermined ] observation, take for applied voltage to rise from 0V, and an intensity level once rises from an init level, and reaches peak value. It has after that an electrical-potential-difference-brightness property which descends up to abbreviation 0 level, and is characterized by making into the driver voltage range the range of the electrical-potential-difference value from which the intensity level in said brightness-voltage characteristic serves as peak value, and the electrical-potential-difference value from which an intensity level turns into abbreviation 0 level. According to the above-mentioned configuration, a display brighter than the conventional example is possible, and the liquid crystal display of a normally white which can prevent tone reversal can be realized. Moreover, invention of claim 3 is set to the liquid crystal display in the dispersion mode which displays by changing a liquid crystal layer to a dispersion condition and a transparency condition. It is the normally black from which said dispersion mode serves as a dark status display in the state of transparency at the time of no electrical-potential-difference impressing. When it observes from [ predetermined ] observation, brightness is abbreviation 0 level until applied voltage reaches threshold voltage from 0V. If applied voltage exceeds threshold voltage, will take to the rise of applied voltage, and an intensity level rises, and peak value is reached. It has the descending electrical-potential-difference-brightness property after that, and is characterized by making into the driver voltage range the range of said threshold voltage value to which the intensity level in said brightness-voltage characteristic begins to change from 0 level, and the electrical-potential-difference value from which an intensity level serves as peak value. According to the above-mentioned configuration, a display brighter than the conventional example is possible, and the liquid crystal display of a normally black which can prevent tone reversal can be realized. Moreover, invention of claim 4 is invention of claim 2, and is characterized by making into the driver voltage range the range of the highest electrical-potential-difference value and the electrical-potential-difference value from which said intensity level turns into abbreviation 0 level among the electrical-potential-difference values from which two or more peak value of the intensity level in said brightness-voltage characteristic exists, and turns into each peak value.

[0006] Moreover, it is characterized by making the range of the lowest electrical-potential-difference value into the driver voltage range among said threshold voltage value to which invention of claim 5 is invention of claim 3, two or more peak value of the intensity level in said brightness-voltage characteristic exists, and said intensity level begins to change from 0 level, and the electrical-potential-difference value from which it becomes said each peak value.

[0007] Moreover, invention of claim 6 is invention of claim 1, and is characterized by setting up said observation direction in the direction of outgoing radiation of the light by which outgoing radiation is carried out from a liquid crystal layer in the transparency condition of a liquid crystal layer to a front side, and the different direction.

[0008] Moreover, invention of claim 7 is invention of claim 2, and is characterized by setting up said observation direction in the direction of outgoing radiation of the light by which outgoing radiation is carried out from a liquid crystal layer in the transparency condition of a liquid crystal layer to a front side, and the different direction.

[0009] Moreover, invention of claim 8 is invention of claim 3, and is characterized by setting up said

observation direction in the direction of outgoing radiation of the light by which outgoing radiation is carried out from a liquid crystal layer in the transparency condition of a liquid crystal layer to a front side, and the different direction.

[0010] Moreover, invention of claim 9 is invention of claim 2, and is characterized by carrying out a bias drive.

[0011] Moreover, invention of claim 10 is invention of claim 3, and is characterized by carrying out a bias drive.

[0012] Moreover, invention of claim 11 is invention of claim 9, and is characterized by being constituted so that the bias voltage in said bias drive can be adjusted.

[0013] Moreover, invention of claim 12 is invention of claim 10, and is characterized by being constituted so that the bias voltage in said bias drive can be adjusted.

[0014] Moreover, invention of claim 13 is invention of claim 1, and is characterized by having a driver voltage adjustment means to adjust so that driver voltage may become said driver voltage range, according to change of said brightness-voltage characteristic.

[0015] Moreover, invention of claim 14 is invention of claim 2, and is characterized by having a driver voltage adjustment means to adjust so that driver voltage may become said driver voltage range, according to change of said brightness-voltage characteristic.

[0016] Moreover, invention of claim 15 is invention of claim 3, and is characterized by having a driver voltage adjustment means to adjust so that driver voltage may become said driver voltage range, according to change of said brightness-voltage characteristic.

[0017] Moreover, invention of claim 16 is invention of claim 13, and while having a detection means to detect the electrical potential difference corresponding to the peak value of said intensity level mostly, said driver voltage adjustment means is characterized by being constituted so that driver voltage may be adjusted according to the above-mentioned detection result.

[0018] Moreover, invention of claim 17 is invention of claim 14, and while having a detection means to detect the electrical potential difference corresponding to the peak value of said intensity level mostly, said driver voltage adjustment means is characterized by being constituted so that driver voltage may be adjusted according to the above-mentioned detection result.

[0019] Moreover, invention of claim 18 is invention of claim 15, and while having a detection means to detect the electrical potential difference corresponding to the peak value of said intensity level mostly, said driver voltage adjustment means is characterized by being constituted so that driver voltage may be adjusted according to the above-mentioned detection result.

[0020] Moreover, invention of claim 19 is invention of claim 13, and while having a detection means to detect the temperature of the busy condition of a liquid crystal display, the above-mentioned driver voltage adjustment means is characterized by being constituted so that driver voltage may be adjusted according to the above-mentioned detection result.

[0021] Moreover, invention of claim 20 is invention of claim 14, and while having a detection means to detect the temperature of the busy condition of a liquid crystal display, the above-mentioned driver voltage adjustment means is characterized by being constituted so that driver voltage may be adjusted according to the above-mentioned detection result.

[0022] Moreover, invention of claim 21 is invention of claim 15, and while having a detection means to detect the temperature of the busy condition of a liquid crystal display, the above-mentioned driver voltage adjustment means is characterized by being constituted so that driver voltage may be adjusted according to the above-mentioned detection result.

[0023] Moreover, invention of claim 22 is invention of claim 1, and the reflecting plate which makes it reflect and carries out outgoing radiation of the light which carries out incidence from the front side of said liquid crystal layer to a front side is characterized by preparing for the back side of said liquid crystal layer.

[0024] Moreover, invention of claim 23 is invention of claim 2, and the reflecting plate which makes it reflect and carries out outgoing radiation of the light which carries out incidence from the front side of said liquid crystal layer to a front side is characterized by preparing for the back side of said liquid crystal layer.

[0025] Moreover, invention of claim 24 is invention of claim 3, and the reflecting plate which makes it reflect and carries out outgoing radiation of the light which carries out incidence from the front side of said liquid crystal layer to a front side is characterized by preparing for the back side of said liquid crystal layer. According to the above-mentioned configuration, a display brighter than the conventional example is possible, and the liquid crystal display of the reflective mold which can prevent tone reversal can be realized. Moreover, invention of claim 25 is invention of claim 1, and is characterized by equipping the

back side of said liquid crystal layer with the light source, and for the light of the direction of slant from the light source passing a liquid crystal layer, and carrying out outgoing radiation to a front side.

[0026] Moreover, invention of claim 26 is invention of claim 2, and is characterized by equipping the back side of said liquid crystal layer with the light source, and for the light of the direction of slant from the light source passing a liquid crystal layer, and carrying out outgoing radiation to a front side.

[0027] Moreover, invention of claim 27 is invention of claim 3, and is characterized by equipping the back side of said liquid crystal layer with the light source, and for the light of the direction of slant from the light source passing a liquid crystal layer, and carrying out outgoing radiation to a front side. According to the above-mentioned configuration, a display brighter than the conventional example is possible, and the liquid crystal display of the transparency mold which can prevent tone reversal can be realized. Moreover, invention of claim 28 is invention of claim 1, and is characterized by displaying by active-matrix drive.

[0028] Moreover, invention of claim 29 is invention of claim 2, and is characterized by displaying by active-matrix drive.

[0029] Moreover, invention of claim 30 is invention of claim 3, and is characterized by displaying by active-matrix drive. According to the above-mentioned configuration, a display brighter than the conventional example is possible, and the liquid crystal display of the active-matrix mold which can prevent tone reversal can be realized. Moreover, invention of claim 31 is invention of claim 1, and is characterized by displaying by passive-matrix drive.

[0030] Moreover, invention of claim 32 is invention of claim 2, and is characterized by displaying by passive-matrix drive.

[0031] Moreover, invention of claim 33 is invention of claim 3, and is characterized by displaying by passive-matrix drive. According to the above-mentioned configuration, a display brighter than the conventional example is possible, and the liquid crystal display of the passive-matrix mold which can prevent tone reversal can be realized. Moreover, invention of claim 34 is characterized by carrying out a bias drive in the drive approach of the liquid crystal display in the dispersion mode which displays by changing a liquid crystal layer to a dispersion condition and a transparency condition.

[0032] Moreover, invention of claim 35 is invention of claim 34, and is characterized by performing the active drive by the active component array.

[0033] Moreover, invention of claim 36 is invention of claim 34, and is characterized by said bias drive being an opposite reversal drive.

[0034] Moreover, invention of claim 37 is invention of claim 34, and is characterized by said bias drive being a floating-gate drive.

[0035] Moreover, invention of claim 38 is invention of claim 34, and is characterized by said bias drive being a capacity-coupling drive.

[0036] Moreover, invention of claim 39 is invention of claim 34, and is characterized by said predetermined electrical potential difference which said bias driving means generates being adjustable.

[0037] Moreover, in the liquid crystal display in the dispersion mode which displays by changing a liquid crystal layer to a dispersion condition and a transparency condition, invention of claim 40 is characterized by having the brightness-voltage characteristic to which an intensity level with applied voltage higher than the intensity level in 0V exists in the process of the dispersion condition of a liquid crystal layer, and a transparency condition, when it observes from [ predetermined ] observation.

[0038] Moreover, invention of claim 41 is invention of claim 40, and is characterized by making into the driver voltage range the range to an electrical-potential-difference value in said brightness-voltage characteristic where an intensity level carries out monotone reduction, and turns into abbreviation 0 level from the electrical-potential-difference value from which said applied voltage serves as an intensity level higher than the intensity level in 0V.

[0039] Moreover, invention of claim 42 is invention of claim 40, and is characterized by being constituted so that said applied voltage which changes according to the service temperature of a liquid crystal display may become [ an intensity level higher than the intensity level in 0V ] the highest at service temperature within the limits.

[0040] Moreover, invention of claim 43 is invention of claim 40, and is characterized by being constituted so that the intensity level with said applied voltage higher than the intensity level in 0V which changes according to the service temperature of a liquid crystal display may become the highest in a room temperature mostly.

[0041] Moreover, invention of claim 44 is invention of claim 40, and liquid crystal phase-isotropic phase transition temperature in the liquid crystal ingredient which constitutes said liquid crystal layer is characterized by being higher than the upper limit of the operating temperature limits of a liquid crystal display 20 degrees C or more.

[0042] Moreover, invention of claim 45 is invention of claim 40, and liquid crystal phase-isotropic phase transition temperature in the liquid crystal ingredient which constitutes said liquid crystal layer is characterized by being 80 degrees C or more.

[0043] Moreover, invention of claim 46 is invention of claim 1, and is characterized by being constituted so that the peak value of said intensity level which changes according to the service temperature of a liquid crystal display may become the highest at service temperature within the limits.

[0044] Moreover, invention of claim 47 is invention of claim 1, and is characterized by being constituted so that the peak value of said intensity level which changes according to the service temperature of a liquid crystal display may become the highest in a room temperature mostly.

[0045] Moreover, invention of claim 48 is invention of claim 1, and liquid crystal phase-isotropic phase transition temperature in the liquid crystal ingredient which constitutes said liquid crystal layer is characterized by being higher than the upper limit of the operating temperature limits of a liquid crystal display 20 degrees C or more.

[0046] Moreover, invention of claim 49 is invention of claim 1, and liquid crystal phase-isotropic phase transition temperature in the liquid crystal ingredient which constitutes said liquid crystal layer is characterized by being 80 degrees C or more. By these, effect by the temperature dependence of magnitude  $\Delta n$  of the refractive-index anisotropy of a liquid crystal ingredient can be lessened, and high brightness and contrast can be acquired by service temperature within the limits.

[0047] moreover, the case where invention of claim 50 is invention of claim 1, and dispersion gain of  $d$  (micrometer) and said liquid crystal layer is set to  $SG$  for the thickness of said liquid crystal layer --  $50\exp(-0.4d) < SG < 360\exp(-0.47d)$

It is characterized by \*\*\*\*\*.

[0048] moreover, the case where invention of claim 51 is invention of claim 1, and the birefringence anisotropy of a liquid crystal ingredient [ in  $\Delta n$ , for the dispersion gain of  $d$  (micrometer) and said liquid crystal layer / in the thickness of said liquid crystal layer /  $SG$  and said liquid crystal layer ] is set to  $\Delta n$  --  $50\exp(-1.6\Delta n-d) < SG < 360\exp(-1.88\Delta n-d)$

It is characterized by \*\*\*\*\*.

[0049] Moreover, invention of claim 52 is invention of claim 1, and is characterized by the dispersion gain of said liquid crystal layer being 10 or more and 200 or less.

[0050] Moreover, invention of claim 53 is invention of claim 1, and dispersion gain of said liquid crystal layer of service temperature within the limits of a liquid crystal display is characterized by being 10 or more and 200 or less. The correlation shown in drawing 20 is between dispersion gain and contrast. The dispersion gain used as the maximum contrast exists in every thickness [ of a polymer dispersed liquid crystal layer ] (it is equivalent to panel gap.)  $d$  so that clearly from this drawing 20. Then, in drawing 20, when 70% or more of range of the maximum contrast is made into a setting range, the relation of the panel gap  $d$  and dispersion gain which are shown in drawing 2121 is obtained. In drawing 21, Rhine P1 shows the upper limit of the tolerance of dispersion gain, and Rhine P3 shows the minimum of the tolerance of dispersion gain. Therefore, if dispersion gain is set up within the limits of this Rhine P1 and Rhine P3, 70% or more of contrast of the maximum contrast will be acquired. Here, Rhine P1 is  $SG=360\exp(-0.47d)$ , and Rhine P3 is  $SG=50\exp(-0.4d)$ . therefore, the dispersion gain  $SG$  of a polymer dispersed liquid crystal layer --  $50\exp(-0.4d) < SG < 360\exp(-0.47d)$

\*\*\*\*\* -- if it produces like, 70% or more of contrast of the maximum contrast will be acquired, and the polymer dispersed liquid crystal display device of the reflective mold of high brightness and high contrast will be realized.

[0051]

[Embodiment of the Invention] Hereafter, the gestalt of operation of this invention is explained based on a drawing. The gestalt of this operation can attain raise in brightness, and high contrast-ization by setting up driver voltage appropriately.

(Outline of the gestalt of operation) Drawing 1 is the sectional view which the liquid crystal display concerning the gestalt of operation simplified. The liquid crystal display 301 concerning the gestalt of this operation is a liquid crystal display of a reflective mold. This liquid crystal display 301 has the liquid crystal layer 305 arranged between the bottom substrate 302, the upper substrate 303 which counters the bottom substrate 302, the reflecting plate 304 which consists of aluminum, and a reflecting plate 304 and the upper substrate 303. This liquid crystal layer 305 consists of dispersion liquid crystal which displays by the change of a dispersion condition and a transparency condition. As dispersion liquid crystal, a polymer dispersed liquid crystal, dynamic scattering mold liquid crystal (DSM:dynamic scattering mode), cholesteric NEMATEKKU phase transition mold liquid crystal, etc. are illustrated, for example.

[0052] Drawing 2 is drawing for explaining the display action of a liquid crystal display 301, and drawing

3 is a graph which shows the brightness-voltage characteristic of a liquid crystal display 301. This liquid crystal display 301 is a dispersion mold liquid crystal display of the so-called normally white in which bright state is shown in the state of dispersion at the time of no electrical-potential-difference impressing. When the display action of this liquid crystal display is explained and it is 0V at the time of no electrical-potential-difference impressing, i.e., applied voltage, since the liquid crystal layer 305 serves as dispersion mode, as shown in drawing 2 (a), incident light L1 is reflected in a front-face side by the reflecting plate 304, and this reflected light turns into the scattered light. Since the dispersion conditions at this time are scattered on homogeneity about all directions (method dispersion of a grade), if they show a dispersion condition typically in the flat surface containing space for convenience, as a reference mark A1 shows, they will serve as a perfect circle. the direction of outgoing radiation of the outgoing radiation light (it is equivalent to specular reflection light) L2 by which outgoing radiation is carried out from a liquid crystal layer in the transparency condition of the liquid crystal layer 305 in the observation direction M1 here to a front side, and a different direction -- [ (it shall be set as drawing 2 (d)) ] That is, it makes to avoid and see only specular reflection light into observation conditions. Therefore, such observation conditions are not especially unnatural as an observation mode of a liquid crystal display screen.

[0053] If it observes such from [ M1 ] observation, thereby, a part of scattered light will serve as a display of bright state in accordance with the observation direction M1. If the brightness-voltage characteristic shows the condition which shows in this drawing 2 (a), as shown in drawing 3 , brightness will become about about 40%.

[0054] Subsequently, if applied voltage rises from 0V, the dispersion condition falls. However, if the dispersion condition falls, the dispersion range becomes small gradually and the reflected light will be [ that it should converge in the fixed direction ] in an ellipse dispersion condition as [ show / a reference mark A2 ]. Therefore, the amount of reflected lights which is in agreement in the fixed observation direction M1 becomes large gradually. And if applied voltage reaches \*\*\*\* (=2.5V), the amount of reflected lights which is in agreement in the observation direction M1 will serve as max, and as shown in drawing 3 , the 70% of the maximum brightness will be obtained.

[0055] And when applied voltage exceeds \*\*\*\*, the dispersion range becomes still smaller towards the convergence direction (the direction of the reflected light L2), and the reflected light will shift [ fixed / M1 ] from observation. Therefore, brightness takes and decreases to the increment in applied voltage, as shown in drawing 3 . And when applied voltage is V1 (=4V), brightness falls to about 35% smaller than 40% of brightness at the time of no early electrical-potential-difference impressing. And when applied voltage is V2 (=6.5V), it will be in the condition which shows in drawing 2 (d), and brightness serves as 0% of abbreviation, as shown in drawing 3 .

[0056] In addition, under the condition of the following [ liquid crystal display / 301 ], this invention person experiments in the brightness-voltage characteristic shown in above-mentioned drawing 3 , and it is acquired.

[0057] Cel thickness: Whenever [ incident angle / of 9 micrometer incident light ], to the theta 1:30-degree observation direction and a substrate, with the liquid crystal display 301 in in the include-angle (viewing angle) theta2:15 degree to accomplish, thus dispersion mode with a perpendicular direction, brightness once rises [ the brightness I at the time of no electrical-potential-difference impress ] by electrical-potential-difference impression, peak value  $I_p$  (= 70) is reach, he decreases after that, and become 0% of abbreviation finally is understand. Therefore, in the liquid crystal display 301 concerning the gestalt of this operation, if applied voltage is set as the electrical-potential-difference value \*\*\*\* from which brightness serves as peak value  $I_p$ , the maximum brightness can be obtained. Therefore, it faces driving the liquid crystal display concerning the gestalt of this operation, and a display brighter than the conventional example is attained by making the range of the electrical-potential-difference value V2 used as the electrical-potential-difference value \*\*\*\* and the abbreviation minimum brightness corresponding to the maximum brightness (the gestalt of this operation 2.5 the range of V-6.5V) into the drive range. Moreover, by driving in the above-mentioned drive range, a peak will not exist in an electrical-potential-difference-brightness property and it prevents tone reversal arising. In addition, if the electrical-potential-difference value V2 used as the minimum brightness is an electrical-potential-difference value which is not limited to 6.5V and serves as brightness of 0% of abbreviation, it is enough. moreover, also although it is in the full dispersion condition and excels with the gestalt of the above-mentioned operation at the time of no electrical-potential-difference impressing, this invention is not limited to this, and if it is a liquid crystal display which has dispersion reinforcement which will be in the ellipse dispersion condition near full dispersion from the ellipse dispersion condition shown in drawing 2 (b) at least at the time of no electrical-potential-difference impressing, it will come

out enough.

[0058] (Other matters)

(1) With the gestalt of the above-mentioned implementation, also although it explains and excels about the liquid crystal display of a reflective mold, this invention can be suitably carried out also about the liquid crystal display of a transparency mold.

[0059] (2) Moreover, to the drive method by bias voltage, for example, an opposite reversal drive, a capacity-coupling drive, and a pan, this invention can be suitably carried out also about FG (floating gate) drive.

[0060] (3) Furthermore, this invention can be carried out suitable for any liquid crystal display of a active-matrix mold and a passive-matrix mold, if it is the liquid crystal display in dispersion mode.

[0061] In addition, the concrete contents of above-mentioned (1) - (3) are explained below at a detail.

(Gestalt 1 of operation) The gestalt 1 of operation is explained more concretely hereafter.

[0062] Drawing 4 is the sectional view of liquid crystal display 301A of macromolecule distributed process input output equipment concerning the gestalt 1 of operation. The same reference mark is given to the part corresponding to the liquid crystal display explained in the outline of the gestalt of the above-mentioned implementation. This liquid crystal display 301A is constituted using a polymer dispersed liquid crystal as dispersion mold liquid crystal which constitutes liquid crystal layer 305A. This liquid crystal display 301A was manufactured by the general approach. That is, lamination and an empty cel are manufactured for the glass substrate (equivalent to the bottom substrate 302) with which the reflecting plate 304 was formed in the front face, and the glass substrate (equivalent to the upper substrate 303) with which the ITO electrode was formed through a sealing compound. Subsequently, the mixed solution (for example, PNM201 by Dainippon Ink, Inc.) of liquid crystal and a macromolecule was poured in by the vacuum pouring-in method into said empty cel. Then, using the high-pressure mercury lamp, ultraviolet rays were irradiated for 60 seconds by exposure on-the-strength 20 mW/cm<sup>2</sup>, according to photopolymerization of a macromolecule, phase separation of liquid crystal and the macromolecule was carried out, and liquid crystal layer 305A of a dispersion mold was produced. In addition, cel thickness could be 9 micrometers.

[0063] Subsequently, when the electrical-potential-difference-brightness property of liquid crystal display 301A of the above-mentioned configuration was measured under conditions (theta1:30 degree and viewing-angle theta2:15 degree) whenever [ incident angle ], the same curve as drawing 3 was obtained. Therefore, it is admitted by driving in liquid crystal display 301A of macromolecule distributed process input output equipment in the range (the range of 2.5V-6.5V) of the electrical-potential-difference value \*\*\*\* corresponding to the maximum brightness, and the electrical-potential-difference value V2 corresponding to the minimum brightness that a display brighter than the conventional example is attained, and tone reversal can be prevented.

[0064] In addition, although you may make it generate the electrical potential difference of the above-mentioned range by the drive circuit which may be outputted to the electrical potential difference of 0V - an upper limit in order to drive on the electrical potential difference of the above range, you may make it use the drive circuit which generates the electrical potential difference of the difference of the electrical potential difference of an upper limit and a minimum, and the bias circuit which generates the electrical potential difference of a minimum. In the case of the latter, since the absolute value of the electrical potential difference which a drive circuit outputs becomes low, it can perform using a pressure-proof low thing as a transistor which constitutes a drive circuit etc.

(Gestalt 2 of operation) Drawing 5 is the sectional view of the liquid crystal display concerning the gestalt 2 of operation. The example of liquid crystal display 301B of the active-matrix mold of color display is shown by the gestalt 2 of this operation. If the main component of liquid crystal display 301B is explained, as a bottom substrate, the active-matrix substrate 310 is used and the thin film transistor (TFT:Thin Film Transistor) 311 which consists of an amorphous silicon is formed on this active-matrix substrate 310. This active-matrix substrate 310 is countered and the opposite substrate 313 with which the ITO electrode 312 as a counterelectrode was formed is arranged. Moreover, the color filter 314 and the black matrix 315 are formed in the inside front face of this ITO electrode 312. In addition, in drawing 5, 316 is a reflective pixel electrode which consists of aluminum etc.

[0065] In case an opposite reversal drive is performed using the above-mentioned liquid crystal display 301B, the bias voltage value impressed for an opposite reversal drive will be driven in the electrical-potential-difference value \*\*\*\* corresponding to the peak brightness of the brightness-voltage characteristic, then the drive range of drawing 3, and the brightest display is attained. When this invention person actually impressed the bias voltage of Abbreviation 2-3V and performed the opposite reversal drive, the display brighter than the time of no electrical-potential-difference impressing was

obtained. Moreover, in the halftone display, there was no tone reversal and display grace was also good. [0066] When bias voltage was displayed by 0V for a comparison (the usual drive), it was in the display condition darker than the gestalt 2 of operation. Moreover, when a halftone display was performed, the gradation of a white level was reversed and display grace was spoiled sharply. This is considered to be based on the following reasons. namely, -- the case where bias voltage is set to 0V -- the brightness of these 0V -- about 2 -- it is because a white level rises further rather than the white level set up based on the brightness of 0V since the direction in the case of the applied voltage of -3V has large brightness, so the gradation of a white level is reversed.

[0067] Also although it explains and excels about an opposite reversal drive in the above-mentioned example, it is possible to apply similarly about FG (floating gate) drive (electric information American Communications Association paper magazine: 1991 123P47) which impresses bias voltage, and a capacity-coupling drive (flat-panel display: 1993 P128).

(Gestalt 3 of operation) This invention is applicable not only to a reflective mold liquid crystal display but a transparency mold liquid crystal display. What is necessary is to replace with the reflective pixel electrode 316 of the gestalt 2 of operation, to consider as transparent electrodes, such as ITO, as a concrete configuration, and just to constitute so that a back light may be prepared at the back side of a substrate.

[0068] When the electrical-potential-difference-brightness property was measured about such a transparency mold liquid crystal display, having used the incident angle theta 1 of the incident light from a back light 30 degrees, and having used the viewing angle theta 2 as 15 degrees, the same brightness-electrical-potential-difference curve as drawing 3 was obtained. Moreover, the bright display was obtained by impressing the bias voltage of predetermined magnitude like the gestalt 2 of the above-mentioned implementation. Moreover, although the halftone display was performed, tone reversal did not arise.

(Gestalt 4 of operation) The liquid crystal display concerning the gestalt 4 of operation is a dispersion mold liquid crystal display of the so-called normally black in which a dark display condition is shown in the state of transparency at the time of no electrical-potential-difference impressing. The liquid crystal display concerning the gestalt 4 of operation was manufactured by the approach of a publication to JP,9-817630,A using the active-matrix substrate. In addition, cel thickness could be 15 micrometers.

[0069] About the liquid crystal display manufactured by the above-mentioned approach, when the brightness-voltage characteristic was measured on conditions (theta1=30 degree and viewing-angle theta2=15 degree) whenever [ incident angle / of incident light ], the curve shown in drawing 6 which reversed the curve shown in drawing 3 was obtained. That is, it was the brightness-voltage characteristic which brightness is abbreviation 0 level until applied voltage reaches threshold voltage  $V_{th}$  (=1.8V) from 0V, and will take to the rise of applied voltage if applied voltage exceeds threshold voltage  $V_{th}$ , an intensity level rises, reaches peak value  $I_p$  (70% of intensity levels), and descends after that. In addition, electrical-potential-difference value corresponding to peak value  $I_p$  \*\*\*\* was 5V.

[0070] Why the brightness-voltage characteristic shown in such drawing 6 is acquired is explained below. the dispersion condition of the reflected light since the dispersion condition is contrary to the case of a normally white in the case of a normally black -- fundamental -- drawing 2 -- it will pass through the process of (d) -> drawing 2 R>2(c) -> drawing 2 (b) -> drawing 2 (a). Therefore, the curve shown in drawing 6 is obtained as the brightness-voltage characteristic.

[0071] Thus, peak value  $I_p$  exists in the brightness-voltage characteristic about the case of a normally black as well as the case of a normally white. Therefore, in the liquid crystal display in the case of a normally black, if it drives in the range of the electrical-potential-difference value \*\*\*\* corresponding to the maximum brightness (=5V), and the threshold voltage value  $V_{th}$  (=1.8V), a display brighter than before is attained and generating of tone reversal can be prevented.

(Gestalt 5 of operation) With the gestalt 5 of this operation, this invention was applied to the liquid crystal display of the passive-matrix mold which used the passive-matrix substrate. Scan electrode voltage [ in / in this liquid crystal display, it faces performing the passive-matrix drive based on the electrical-potential-difference equalizing method, and / in a scan electrode / ON period (scanning-line selection period) ] VD Signal-electrode electrical potential difference VS If the sum (VD+VS) sets up pixel electrode voltage (VD+VS) so that it may become an electrical-potential-difference value corresponding to the above-mentioned peak brightness, it is possible to display sufficient brightness. It is because it will drive in the electrical-potential-difference range (\*\*\*\*-V2) in the electrical-potential-difference-brightness property substantially shown in drawing 3 by setting pixel electrode voltage (VD+VS) as the electrical-potential-difference value corresponding to the above-mentioned peak brightness.

[0072] In addition, this invention person performed the false passive-matrix drive based on the

electrical-potential-difference equalizing method using the liquid crystal display of the gestalten 1-4 of the above-mentioned implementation by reference. Consequently, display grace sufficient also by passive-matrix drive was able to be acquired. Moreover, 16 became the display also with the beautiful number of scanning lines. (By making the gamma property of an electrical-potential-difference brightness property make it steep, it becomes possible to make the number of scanning lines increase further.) In addition, "a false passive-matrix drive" means having driven by regarding it as a passive-matrix substrate, although the substrate of a pair is not an object for passive-matrix substrates.

(Gestalt 6 of operation) Drawing 7 is the perspective view of the reflecting plate used in the reflective mold liquid crystal display concerning the gestalt 6 of operation, and drawing 8 is the sectional view of drawing 7. With the gestalt 6 of this operation, the "RITORO reflector" was used as a reflecting plate 320. A "RITORO reflector" means the reflecting plate which has the description which reflects the light which entered in the direction of incidence here. Use of this reflecting plate 320 generates reflection very strong against the direction of the light source. However, unless it is a very special service condition, the direction of the light source and the observation direction are not in agreement. When an observer exists in the direction of the light source, it is because an observer's shadow is made. Therefore, even if it returns the reflected light to a light source side, it is satisfactory in any way practically. Then, by using the above-mentioned reflecting plate 320, the reflected light will be avoided and seen and the observation conditions of the brightness-voltage characteristic in this invention can be satisfied. Therefore, if it drives also in the reflective mold liquid crystal display concerning the gestalt 6 of such operation in the range of the electrical-potential-difference value used as the electrical-potential-difference value \*\*\*\* used as the maximum brightness, and the minimum brightness, a display brighter than before is attained and generating of tone reversal can be prevented.

(Gestalt 7 of operation) The temperature dependence of the brightness-voltage characteristic in a liquid crystal display and its optimization are explained.

[0073] The liquid crystal display (however, a cel gap 7 micrometers) shown with the gestalt 1 of said operation came to be shown in drawing 9, when the temperature change of the brightness-voltage characteristic was measured. Moreover, what plotted the electrical potential difference from which brightness becomes a peak to temperature is shown in drawing 10.

[0074] As shown in these drawings, the electrical potential difference from which brightness becomes a peak is shifted according to service temperature. The temperature dependence of such the brightness-voltage characteristic originates in magnitude deltan of the refractive-index anisotropy of for example, a liquid crystal ingredient changing with temperature etc. So, in order to acquire high brightness and contrast in various service temperature, it is desirable to adjust the driver voltage range according to service temperature. In this case, although you may make it adjust the bound of the driver voltage range, since the effect which it has on the existence of the highest brightness, contrast, and tone reversal is large, it is more desirable [ especially the electrical potential difference by the side of the high brightness in the driver voltage range (setting to drawing 9 low-battery side) ] to adjust the electrical potential difference by the side of high brightness at least.

[0075] While forming a temperature sensor 333 near the viewing area 332 of a liquid crystal display 331 as shown, for example in drawing 11 although it may be made to perform the above adjustments manually The data which show the bound electrical potential difference of the driver voltage range according to the output of the above-mentioned temperature sensor 333 to the memory 335 connected to the above-mentioned temperature sensor 333 through the A/D-conversion circuit 334 are made to hold beforehand. The drive circuit 336 may carry out making it output the electrical potential difference of the driver voltage range based on the data read from the above-mentioned memory 335 etc.

[0076] Moreover, as shown, for example in drawing 12, while forming brightness detection field 342a near the viewing area 342 of a liquid crystal display 341, the photosensor 343 connected to the A/D-conversion circuit 344 is formed, the electrical potential difference from which the drive circuit 346 is made to scan driver voltage by control of a control circuit 345, and brightness serves as a peak is detected, and you may make it ask for bias voltage based on a detection result.

[0077] In addition, it may be made to perform detection of the electrical potential difference from which the above brightness serves as a peak to the power up of equipment, and when the effect which it has on image display does not pose a problem, it may be made to carry out into a display action always or periodically. Moreover, although it may be made to perform detection of temperature only to the power up of equipment, since image display is not affected, what is necessary is just made to carry out into a display action always or periodically.

(Gestalt 8 of operation) The temperature dependence of the brightness-voltage characteristic explained with the gestalt 7 of the above-mentioned implementation becomes what changed with the magnitude of a

cel gap, particle size of a liquid crystal drop, etc. The temperature dependence of the brightness-voltage characteristic in case the magnitude of a cel gap is 7 micrometers, 12 micrometers, or 3 micrometers becomes like drawing 9, drawing 13, and drawing 14, respectively, and, specifically, peak brightness becomes the highest at the time of about 20 degrees C, 60 degrees C, and 0 degree C. Thus, it is considered to be based on the following reasons that the temperature from which peak brightness becomes the highest differs. That is, generally,  $\delta$ tan is small at an elevated temperature and becomes large at low temperature, and in connection with this, dispersion reinforcement is small at an elevated temperature, and it becomes large at low temperature. On the other hand, the range of dispersion gain where peak brightness becomes the highest becomes settled with the magnitude of a cel gap etc., and peak brightness becomes low, even if dispersion gain is larger than this range (the optimal range) and it is small. So, it is thought that the brightness-voltage characteristic changes according to service temperature as mentioned above.

[0078] then -- for example, the thing for which the magnitude of  $\delta$ tan in the magnitude of a cel gap, the particle size of a liquid crystal drop, and predetermined temperature etc. is appropriately set up so that peak brightness may become the highest in service temperature, such as 0-60 degrees C, 10-40 degrees C, and 20-30 etc. degrees C, -- high brightness -- and -- high -- a contrast image can be displayed.

[0079] Moreover, as for  $\delta$ tan of a liquid crystal ingredient, it is fundamentally desirable that there is little temperature dependence. Here,  $\delta$ tan has the property which increases rapidly from the time of generally a liquid crystal ingredient carrying out phase transition to a liquid crystal phase from the isotropic phase by the side of an elevated temperature. So, in order to reduce the effect of the temperature dependence of  $\delta$ tan in operating temperature limits, it is desirable that the phase transition temperature of a liquid crystal ingredient is high. Then, as a result of this invention person's examining many things, when phase transition temperature was preferably higher than the upper limit of operating temperature limits about 20 degrees or more about 15 degrees C or more, it turned out that it is satisfactory on use. Moreover, when phase transition temperature was 80 degrees C or more, although the limit like an ingredient became large, it turned out that a use top is satisfactory too.

(Gestalt 9 of operation) When unsymmetrical surface treatment was performed to one pair of substrates holding for example, a liquid crystal layer, as shown in drawing 15, the peak of two or more brightness might produce the brightness-voltage characteristic. In such a case, it can perform easily displaying the good image of gradation nature by gamma amendment, without producing the electrical potential difference of the range as for which brightness carries out monotone reduction, applying to the electrical potential difference to which brightness serves as about 0 level from the electrical potential difference which the peak of the brightness of the one where an electrical potential difference is higher produces for the driver voltage range, then tone reversal, etc.

(Gestalt 10 of operation) The gestalt 10 of operation of this invention is hereafter explained based on a drawing. The gestalt of this operation can attain raise in brightness, and high contrast-ization by setting up appropriately dispersion gain, the product of the magnitude of the refractive-index anisotropy of liquid crystal, and the thickness of a liquid crystal layer, etc.

[0080] Drawing 16 is the sectional view which the liquid crystal display component 101 concerning the gestalt 10 of operation of this invention simplified. The liquid crystal display component 101 is a liquid crystal display component of a reflective mold, and is a liquid crystal display component of a normally white mode. The liquid crystal display component 101 has the polymer dispersed liquid crystal layer 104 arranged between the array substrate 102, the opposite substrate 103 which counters the array substrate 102 and is arranged, and the array substrate 102 and the opposite substrate 103. The array substrate 102 and the opposite substrate 103 are transparent substrates which consist of glass. On this array substrate 102, the thin film transistor (TFT) as the source line 106, the reflective pixel electrode 105 which consists of the metal which has reflexivity, and a pixel switching element etc. is formed. The reflective pixel electrode 105 consists of aluminum (aluminum) or chromium (Cr). These source line 106, the reflective pixel electrode 105, TFT, etc. are covered with the insulator layer 107. The transparent counterelectrode 109 and the insulator layer 110 are formed in the medial surface of said opposite substrate 103 in the shape of a laminating in this sequence.

[0081] Moreover, said polymer dispersed liquid crystal layer 104 is made into the structure where the liquid crystal drop 112 was distributed in the macromolecule 111, and, as for the liquid crystal in the liquid crystal drop 112, that whose dielectric constant anisotropy is forward is used.

[0082] Here, as for the polymer dispersed liquid crystal layer 104, the dispersion gain SG is filling the following relation of the 1st formula. Here, if its dispersion nature is small when the dispersion gain SG is defined by  $SG = (\text{panel brightness} / \text{panel illuminance}) \times \pi$  and is large, and dispersion gain is small, dispersion nature means a large thing. [ of dispersion gain ] In addition, the dispersion gain over green

light was used for dispersion gain.

[0083]

$50\exp(-0.4d) < SG < 360\exp(-0.47d)$

-- (1)

d is the thickness (a panel gap is called hereafter.) of the polymer dispersed liquid crystal layer 104.

[0084] by setting up so that the dispersion gain of the polymer dispersed liquid crystal layer 104 may fill the 1st formula as mentioned above, compared with the conventional example, it is markedly alike, and quantity brightness and the reflective mold liquid crystal display component of high contrast can be realized. In addition, dispersion gain is behind explained in full detail about these, although it can set up with magnitude  $\Delta n$  of for example, a refractive-index anisotropy, product  $\Delta n d$  with the panel gap d, the magnitude of a liquid crystal drop, etc.

[0085] Moreover, although it is the case where magnitude  $\Delta n$  of the refractive-index anisotropy in the room temperature in the liquid crystal in the liquid crystal drop 112 is 0.25 in general, that high brightness and high contrast are acquired by filling the 1st formula of the above the case of the value (for example, in general 0.15 or more, or less 0.27 extent) of  $\Delta n$  of the liquid crystal ingredient used when the values of  $\Delta n$  differ sharply etc. -- the [ following ] -- high brightness and high contrast can be acquired by setting up so that 1' type may be filled. [ many ]

[0086]

$50\exp(s) (-1.6\Delta n \cdot d) < SG < 360\exp(-1.88\Delta n \cdot d)$

-- (1')

the [ in addition, / the 1st formula of the above, or ] -- the values of the dispersion gain SG with which 1' type is filled are 10 or more and or less 200 extent in general in panel conditions, such as a common liquid crystal ingredient and a panel gap, for example in service temperature within the limits of 10 degrees C or more and 60 degrees C or less.

[0087] The above-mentioned reason will be explained, explaining actuation of the liquid crystal display component concerning this invention below.

[0088] Drawing 17 is drawing for explaining the display action of a reflective mold liquid crystal display component. when a display action is explained with reference to drawing 17, it is shown in drawing 17 (a) at the time of an electrical potential difference OFF -- as -- the liquid crystal in the liquid crystal drop 112 -- an orientation shaft -- mutual -- a three dimension -- being [ therefore ] in random bearing, a panel shows a dispersion condition according to the refractive-index difference of liquid crystal and a macromolecule 113. At this time, the incident light 120 of a panel turns into the scattered light 121, and a white display is obtained. On the other hand, as shown in drawing 17 (b) at the time of an electrical potential difference ON, orientation of the liquid crystal in the liquid crystal drop 112 is mostly carried out in the panel gap direction. Therefore, a panel will be in a transparence condition by refractive-index matching with liquid crystal and the surrounding giant molecule 113. Therefore, dispersion is not received, but it is reflected with a reflective pixel electrode, and incident light 120 is emitted from a panel as a specular reflection light 122. At this time, light is not emitted in the direction of an observer 125, but, as for a panel, a black display is obtained.

[0089] By the way, the electrical potential difference and the reflection factor property of a polymer dispersed liquid crystal display device of having the above-mentioned display action are shown in drawing 18. The property of this drawing 18 is acquired by this invention person's experimental result. In addition, the Measuring condition was made into  $\theta_1=30$  degree and measurement include angle  $\theta_2=15$  degree (refer to drawing 17 (b)) whenever [ incident angle / of incident light ]. This Measuring condition is made to correspond to the view of the criterion of a reflective mold liquid crystal display component.

[0090] After the reflection factor's rising according to the increment in applied voltage and reaching peak value, it decreases, so that clearly from drawing 18. Namely, as for the polymer dispersed liquid crystal display device of a reflective mold, a peak reflection factor exists in its electrical potential difference and reflection factor property. Such existence of a peak reflection factor will not be found out without this invention person's experimental result.

[0091] Here, it is considered to be based on the following principles that a peak reflection factor exists. The principle is explained with reference to drawing 19. In drawing 19, the dispersion bearing distribution 130 showed the dispersion situation of the panel at the time (equivalent to the A point of drawing 18) of no electrical-potential-difference impressing, the dispersion bearing distribution 131 showed the dispersion situation in case a reflection factor serves as max (equivalent to the B point of drawing 18), and the dispersion bearing distribution 132 showed the dispersion situation at the time of impressing an electrical potential difference further (equivalent to C point of drawing 18). In the case of

the macromolecule distributed panel of a normally white mode, with electrical-potential-difference impression, dispersion becomes weak and dispersion bearing distribution is extended in the direction of specular reflection of incident light. At this time, the dispersion bearing distribution 131 has a reflection factor higher than the dispersion bearing distribution 130 from the location of the observer 125 of drawing 19. Furthermore, if an electrical potential difference is impressed, it will become the dispersion bearing distribution 132 mostly converged in the direction of specular reflection, and the reflection factor of observer 125 direction will decrease. For this reason, a peak occurs in the reflection factor of an electrical potential difference and a reflection factor property. this invention person found out that raise in brightness and high contrast-ization could be attained by making into the driver voltage range the range of the electrical-potential-difference value from which it becomes a peak to make the intensity level in a peak reflection factor into white brightness, i.e., an intensity level, and the electrical-potential-difference value from which an intensity level turns into about 0 level, or the range of the electrical-potential-difference value in which brightness carries out monotone reduction from the above-mentioned peak paying attention to this electrical potential difference and reflection factor property.

[0092] In addition, the mode with which a peak reflection factor exists in an electrical potential difference and a reflection factor property was not known conventionally. this having measured the light reflected in a panel transverse plane to the incident light from slant, and having acquired the electrical potential difference and the reflection factor property -- further Since the dispersion gain SG was set up by one to about two in the case of the transparency mold, the thing of dispersion gain with dispersion gain comparable also about a reflective mold is used, therefore it is thought that it was not that with which a peak reflection factor is small and existence of a peak reflection factor may be recognized to be.

[0093] Here, with reference to drawing 18, the relation between dispersion gain, and an electrical potential difference and a reflection factor property is explained. With the liquid crystal display component of the reflective mold using the conventional black absorption plate, the dispersion gain SG is one to about two. The actual condition is that are set as about SG=1 in order to acquire [ in / in / generally / a transparency mold liquid crystal display component / in this / a dispersion condition (initial state) ] full dispersion, and dispersion gain is set as about SG=1 also in the liquid crystal display component of a reflective mold by the idea of what can realize high brightness and high contrast by acquiring full dispersion. However, according to this invention person's experimental result, as described above, in an electrical potential difference and a reflection factor property, the peak reflection factor (equivalent to peak brightness) exists, and the electrical potential difference and reflection factor property in the case of being SG=1 are shown by Rhine M1 of drawing 18. Therefore, in the conventional example set as SG=1, an intensity level may be larger than electrical-potential-difference the condition of not impressing (in the case of applied-voltage 0V), in fact. In addition, about slanting light, even if a liquid crystal molecule is perpendicular to a substrate in the case of SG=1, since the refractive indexes of a macromolecule and liquid crystal differ, it is completed as the value which is considerably separated from 0% by the reflection factor. Since a black absorption plate is used and the black of a black absorption plate is reflected in black level even if it is in such a condition, even if a reflection factor is not 0%, sufficient black level is obtained. However, contrast is not high.

[0094] On the other hand, although based on other conditions, when a panel gap is comparatively large, the electrical potential difference and reflection factor property in SG=100 are shown by Rhine M2 of drawing 18, for example. That is, after a reflection factor rises a little from an initial state according to the increment in an electrical potential difference, it decreases and converges to about 0%. This is considered that change of dispersion nature is small also to the light from slant, when dispersion gain is large (namely, when dispersion nature is small). Therefore, it is thought that a peak reflection factor also becomes small. On the other hand, since dispersion nature is essentially small, it is completed to about 0% by the reflection factor by the power surge. In this way, even if dispersion gain is small and it is too large, high brightness and high contrast are not acquired. In order to attain a raise in brightness, and high contrast-ization, it is admitted that the optimal dispersion gain exists. According to this invention person's experimental result, about about ten to 20 dispersion gain is an optimum value. Therefore, by setting it as such optimal dispersion gain, the property shown in Rhine M3 of drawing 18 is acquired, and a raise in brightness and high contrast-ization can be attained.

[0095] On the other hand, the dispersion gain from which predetermined contrast is acquired has a panel gap and a correlation, and in order to acquire the optimal dispersion gain, it is necessary to take the value of a panel gap into consideration. Then, in order to search for the optimal dispersion gain concretely, the relation of the dispersion gain and contrast which evaluate the polymer dispersed liquid crystal panel which has various dispersion engine performance, consequently are shown in drawing 20 was obtained.

In addition, the dispersion gain measured by the transparency mold panel was used for dispersion gain. Moreover, contrast used the result measured by the same Measuring condition as the case of the above-mentioned electrical potential difference and reflection factor property (whenever [ incident angle / of incident light / theta ]  $\theta = 30$  degrees, the measurement include angle  $\theta = 15$  degrees). The dispersion gain from which contrast serves as max exists, and, moreover, it is admitted that these dispersion gain differs about a panel gap so that clearly from drawing 20. This means that the dispersion gain for acquiring the maximum contrast is determined, if a panel gap is set as a certain value. Here, as a liquid crystal display component concerning this invention, it was desirable to acquire 70% or more of contrast of the maximum contrast, and it decided to ask for the range of the dispersion gain which acquires 70% or more of contrast of the maximum contrast. In addition, the contrast of the reflective mold panel of the conventional example is usually about ten, and even when large, it is about 15. therefore, if it is 70% or more of the maximum contrast, compared with the conventional example, it will be markedly alike, and quantity contrast-ization can be realized.

[0096] It specifically asked for the range of the dispersion gain which acquires 70% or more of contrast of the maximum contrast in the following procedures. Namely, the dispersion gain-contrast property about each panel gap  $d$  (in drawing 20 the property in  $d = 4.5$  micrometers by the reference mark L1) a reference mark L2 shows the property in  $d = 7$  micrometers, and the reference mark L3 shows the property in  $d = 10$  micrometers. It sets and is 70% of contrast (in drawing 20 Rhine m1, m2, and m3  $d = 4.5$  micrometers) of the maximum contrast. 70% of Rhine of the maximum contrast in 7 micrometers and 10 micrometers is shown -- \*\*\*\* -- the dispersion gain to acquire was searched for and the relation of the panel gap and dispersion gain which show this value to drawing 21 by carrying out a sequential plot was obtained. When explaining concretely, the points A1 and A2 of drawing 20, A3;B1, B-2, B3;C1, and C2 and C3 were plotted to drawing 21. Subsequently, the range of the optimal dispersion gain was computed from the relation between the panel gap of drawing 21, and dispersion gain.

[0097] Here, Rhine P1 of drawing 21 shows a tolerance upper limit, Rhine P2 shows the range of the optimal contrast, and Rhine P3 shows a tolerance minimum. Therefore, it is admitted that the range of the dispersion gain SG more nearly optimal than the property of drawing 21 should just be located in the range of Rhine P1 and Rhine P3. If Rhine P1 is indicated by the function, it will be  $SG = 360 \exp(-0.47d)$  here, and if Rhine P3 is indicated by the function, it will be  $SG = 50 \exp(-0.4d)$ . therefore, the range of the optimal dispersion gain SG --  $50 \exp(-0.4d) < SG < 360 \exp(-0.47d)$

It is understood that \*\*\*\*\* is good.

[0098] In addition, if Rhine P2 is indicated by the function, it will be  $SG = 265 \exp(-0.5d)$ . Therefore, if the dispersion gain SG is set as  $265 \exp(s) (-0.5d)$ , the maximum contrast in the panel gap will be acquired.

[0099] Moreover, it was admitted that the relation between the maximum contrast and a panel gap shown in drawing 22 was by experiment of this invention person. The maximum contrast is so higher that a panel gap is small than this drawing 22. However, when a panel gap is less than 3 micrometers, it is difficult to actually produce to homogeneity. On the other hand, if a panel gap exceeds 8 micrometers, since driver voltage will increase, as a reflective mold panel, it is unsuitable. Therefore, as for the panel gap  $d$ , it is desirable to set it as 3 micrometers or more and 8 micrometers or less.

(More concrete example of the gestalt 10 of operation) The more concrete example of the gestalt 10 of the above-mentioned implementation is explained.

[0100] The liquid crystal display component 101 shown in drawing 16 was produced by the following approaches. On the transparence substrate which consists of glass, the reflective pixel electrode 105 grade which consists of a TFT component, the source line 106, and aluminum was formed, and it considered as the array substrate 102. The reflective pixel electrode 105 was used as the flat specular reflection plate at this time. Moreover, the transparent counterelectrode 109 grade was formed on the opposite substrate 103. Subsequently, the up-and-down substrate 102,103 was stuck by panel gap 5micrometer. Next, vacuum impregnation of the polymer dispersed liquid crystal ingredient (trade name: PNM201, Dainippon Ink & Chemicals make) was carried out between substrates 102,103. And the polymer dispersed liquid crystal ingredient irradiated ultraviolet rays, carried out the polymerization of the ingredient to the panel by which vacuum impregnation was carried out, and created the polymer dispersed liquid crystal panel.

[0101] The electrical potential difference and the reflection factor property of the formed panel were measured, and panel evaluation was performed. Thereby, the property of drawing 18 was acquired. Next, many panels into which liquid crystal particle size and a panel gap were changed were created, and the relation between dispersion gain and contrast was evaluated. Thereby, the property of drawing 20 was acquired. In addition, at this time, using the case of a reflective mold panel, and this ingredient, the macromolecule distribution liquid crystal layer of this particle size and this panel gap was separately

created by the transparency mold panel, and dispersion gain was evaluated from the panel transmitted light. Here, contrast was searched for from the value of the peak reflection factor of the direction of 15 degrees of polar angles when carrying out incidence of 30 degrees of polar angles to the light, and the brightness at the time of maximum applying voltage.

[0102] Moreover, the range of the optimal dispersion gain and the relation of a panel gap which are shown in drawing 21 were obtained from drawing 20. The optimal range at this time is range which can realize 70% or more of the maximum contrast. drawing 20 -- the dispersion gain  $SG \sim 50\exp(-0.4d) \sim SG < 360\exp(-0.47d)$

It turns out that high contrast is acquired at the time of  $d$  (micrometer) at this time is a panel gap. Moreover, contrast can be made into max if  $SG=265\exp(-0.5d)$  is filled. When a panel gap is 4.5 micrometers, specifically, the optimal dispersion gain exists in about ten to 40 range. Moreover, as for contrast, a maximum of 55 about were obtained by gain 25. Moreover, as shown in drawing 22, the maximums of contrast differ about a panel gap, and if it is 3 micrometers or more and 8 micrometers or less, 30 or more contrast and a very good display will be obtained.

[0103] In addition, although contrast for asking for the optimal range of dispersion gain was made into 70% or more of the maximum contrast in the above-mentioned example, this may use predetermined contrast, such as 50 etc.% or more etc. of the maximum contrast, if needed. the range where dispersion gain is the optimal in the case of 50% or more of the maximum contrast -- said 70% or more of case -- the same -- drawing 20 --  $37\exp(-0.37d) \sim SG < 275\exp(-0.31d)$  or  $37\exp(s)(-1.48\delta n \cdot d) \sim SG < 275\exp(-1.24\delta n \cdot d)$

It becomes.

[0104] moreover -- the case of 90% of the maximum contrast --  $177\exp(-0.52d) \sim SG < 229\exp(-0.41d)$

or  $177\exp(s)(-2.08\delta n \cdot d) \sim SG < 229\exp(-1.64\delta n \cdot d)$

It becomes.

[0105] In 3 micrometers, the range of the dispersion gain optimal in the case of 70% or more of the maximum contrast is 15 or more and 108 or less, and the panel gap of the optimal dispersion gain is still more specifically 80.

[0106]

[Effect of the Invention] As mentioned above, according to this invention, a display brighter than before is possible and the liquid crystal display of the dispersion mold whose display grace without tone reversal improved can be realized.

#### [Brief Description of the Drawings]

[Drawing 1] It is the sectional view which the liquid crystal display 301 concerning the outline of the gestalt of operation simplified.

[Drawing 2] It is drawing for explaining the display action of the liquid crystal display 301 concerning the outline of the gestalt of operation.

[Drawing 3] It is the graph which shows the brightness-voltage characteristic of the liquid crystal display 301 concerning the outline of the gestalt of operation.

[Drawing 4] It is the sectional view which liquid crystal display 301A concerning the gestalt 1 of operation simplified.

[Drawing 5] It is the sectional view which liquid crystal display 301B concerning the gestalt 2 of operation simplified.

[Drawing 6] It is the graph which shows the brightness-voltage characteristic of the liquid crystal display concerning the gestalt 4 of operation.

[Drawing 7] It is the perspective view of the reflecting plate used in the reflective mold liquid crystal display concerning the gestalt 6 of operation.

[Drawing 8] It is the sectional view of drawing 7.

[Drawing 9] It is drawing showing the temperature change of the brightness-voltage characteristic of the liquid crystal display concerning the gestalt 7 of operation.

[Drawing 10] It is drawing showing the temperature change of the electrical potential difference from which the brightness of the liquid crystal display concerning the gestalt 7 of operation becomes a peak.

[Drawing 11] It is the block diagram showing the configuration of the liquid crystal display equipped with the temperature sensor concerning the gestalt 7 of operation.

[Drawing 12] It is the block diagram showing the configuration of the liquid crystal display equipped with the photosensor concerning the gestalt 7 of operation.

[Drawing 13] It is drawing showing the temperature change of the electrical potential difference from which the brightness of the liquid crystal display concerning the gestalt 8 of operation becomes a peak.

[Drawing 14] It is drawing showing the temperature change of the electrical potential difference from which the brightness of the liquid crystal display concerning the gestalt 8 of operation becomes a peak.

[Drawing 15] It is drawing showing the brightness-voltage characteristic of the liquid crystal display concerning the gestalt 9 of operation.

[Drawing 16] It is the sectional view which liquid crystal display component 101A concerning the gestalt 10 of operation of this invention simplified.

[Drawing 17] It is drawing for explaining the display principle of liquid crystal display component 101A.

[Drawing 18] It is drawing showing the electrical potential difference and the reflection factor property of liquid crystal display component 101A.

[Drawing 19] It is drawing showing the dispersion property of liquid crystal display component 101A.

[Drawing 20] It is drawing showing the relation between dispersion gain and contrast.

[Drawing 21] It is drawing showing the panel gap dependency of dispersion gain required to realize permissible contrast.

[Drawing 22] It is drawing showing a panel gap and the relation of the maximum contrast.

[Drawing 23] It is the graph which shows the brightness-voltage characteristic of the conventional liquid crystal display.

[Description of Notations]

M1 The observation direction

L1 Incident light

L2 Reflected light

101 Liquid Crystal Display Component

102 Array Substrate

103 Opposite Substrate

104 Polymer Dispersed Liquid Crystal Layer

105 Reflective Pixel Electrode

106 Source Line

107 Insulator Layer

109 Counterelectrode

110 Insulator Layer

111 Macromolecule

112 Liquid Crystal Drop

113 Macromolecule

120 Incident Light

121 Scattered Light

122 Specular Reflection Light

125 Observer

130 Dispersion Bearing Distribution

131 Dispersion Bearing Distribution

132 Dispersion Bearing Distribution

301 Liquid Crystal Display

302 Bottom Substrate

303 Upper Substrate

304 Reflecting Plate

305 Liquid Crystal Layer

310 Active-Matrix Substrate

312 ITO Electrode

313 Opposite Substrate

314 Color Filter

315 Black Matrix

316 Reflective Pixel Electrode

320 Reflecting Plate

331 Liquid Crystal Display

332 Viewing Area

333 Temperature Sensor

334 A/D-Conversion Circuit

335 Memory

336 Drive Circuit  
341 Liquid Crystal Display  
342 Viewing Area  
342a Brightness detection field  
343 Photosensor  
344 A/D-Conversion Circuit  
345 Control Circuit  
346 Drive Circuit

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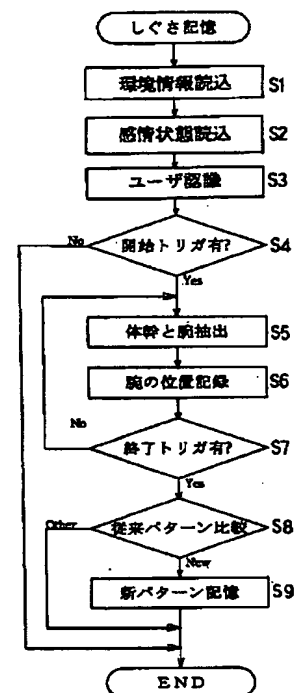
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(54)【発明の名称】 ロボットにおける自律的行動表現システム

(57)【要約】

【課題】ユーザとロボットとの間で親近感が増し、ユーザに飽きられないロボットを提供する。

【解決手段】ユーザ情報を入力するユーザ情報入力手段と、ユーザのしぐさ情報をロボットのしぐさパターンとして記憶する記憶手段と、前記ユーザ情報入力手段に入力された情報に基づいて前記パターンを再生する再生手段とを備える。



## 【特許請求の範囲】

【請求項1】 ユーザ情報を入力するユーザ情報入力手段と、ユーザのしぐさ情報をロボットのしぐさパターンとして記憶する記憶手段と、前記ユーザ情報入力手段に入力された情報に基づいて前記パターンを再生する再生手段とを備えることを特徴とするロボットにおける自律的行動表現システム。

【請求項2】 外部環境情報を入力する外部環境情報入力手段、ロボットの内部状態を入力する入力手段または／および前記ユーザ情報入力手段の情報に基づいて、前記しぐさパターンの記憶、再生の判断を行うことを特徴とする請求項1記載のロボットにおける自律的行動表現システム。

【請求項3】 前記しぐさパターンを複数記憶した場合に、再生時に前記パターンの一つをランダムに選択することを特徴とする請求項1または2記載のロボットにおける自律的行動表現システム。

【請求項4】 前記しぐさパターンを複数記憶した場合に、再生時に前記パターンをユーザ情報、ロボットの感情状態および外部環境情報の少なくとも一つの情報により選択することを特徴とする請求項1または2記載のロボットにおける自律的行動表現システム。

【請求項5】 しぐさパターンの記憶を開始するトリガが、スイッチ、指示音声等のユーザからの特定の行動であることを特徴とする請求項1または2記載のロボットにおける自律的行動表現システム。

【請求項6】 しぐさパターンの記憶を開始するトリガが、ロボットの感情状態のレベルが所定値以上になったときであることを特徴とする請求項1または2記載のロボットにおける自律的行動表現システム。

【請求項7】 しぐさパターンの記憶を開始するトリガが、常にユーザのしぐさの履歴を記憶しておき、ユーザが直前の動作を繰り返した場合であることを特徴とする請求項1または2記載のロボットにおける自律的行動表現システム。

【請求項8】 しぐさパターンの記憶を終了するトリガが、スイッチ、指示音声等のユーザからの特定の行動であることを特徴とする請求項1または2記載のロボットにおける自律的行動表現システム。

【請求項9】 しぐさパターンの記憶を終了するトリガが、開始から一定の時間が経過したときであることを特徴とする請求項1または2記載のロボットにおける自律的行動表現システム。

【請求項10】 しぐさパターンの記憶を終了するトリガが、ユーザが一定時間以上同じ姿勢のままのときであることを特徴とする請求項1または2記載のロボットにおける自律的行動表現システム。

【請求項11】 ユーザ情報を入力するユーザ情報入力手段と、ユーザのしぐさ情報をロボットのしぐさパターンとして記憶する記憶手段と、前記ユーザ情報入力手段に

入力された情報に基づいて前記パターンを再生する再生手段とを備え、前記記憶手段は、ユーザが特定の認識物を手に持つか足や頭に着用することにより、前記認識物を手足などとして検出し、ユーザのしぐさを認識、記憶することを特徴とするロボットにおける自律的行動表現システム。

【請求項12】 前記特定の認識物は、特定の色の付いたマーカであることを特徴とする請求項1記載のロボットにおける自律的行動表現システム。

10 【請求項13】 前記特定の認識物は、特定の光、電波、音波を発信する発振器であることを特徴とする請求項1記載のロボットにおける自律的行動表現システム。

【請求項14】 前記特定の認識物は、特定の光などを反射するマーカであることを特徴とする請求項1記載のロボットにおける自律的行動表現システム。

【請求項15】 前記特定の認識物は、常にロボットに正対するような形状または正対するように保持できる形状であることを特徴とする請求項1ないし14のいずれかに記載のロボットにおける自律的行動表現システム。

20 【発明の詳細な説明】

【0001】

【発明の属する技術分野】 本発明は、玩具用、ゲーム用、民生用、産業用等のロボットにおける自律的行動表現システムに関する。

【0002】

【従来の技術】 最近、学習によりユーザになついたり、独特の動作で感情を表現するなどユーザとのコミュニケーションができるペット型ロボットが商品化されている。例えば、特開平11-58274号公報においては、所望のポーズやモーション情報をロボットに教示する提案を行っている。

【0003】

【発明が解決しようとする課題】 しかしながら、従来の方法は、ティーチングプレイバックによる動作の学習で、ユーザが学習すべき行動を明示的に教えなければならず、自然なインタラクション（相互交流）ではないため、例えばペットロボットのようなインタラクションを主な目的としたロボットとしては、面白みに欠けすぐに飽きられてしまう恐れがある。

40 【0004】 本発明は、上記従来の問題を解決するものであって、ユーザとロボットとの間で親近感が増し飽きがこないロボットにおける自律的行動表現システムを提供することを目的とする。

【0005】

【課題を解決するための手段】 上記目的を達成するために本発明の請求項1記載のロボットにおける自律的行動表現システムは、ユーザ情報を入力するユーザ情報入力手段と、ユーザのしぐさ情報をロボットのしぐさパターンとして記憶する記憶手段と、前記ユーザ情報入力手段に

生手段とを備えることを特徴とし、また、請求項 11 記載の発明は、ユーザ情報を入力するユーザ情報入力手段と、ユーザのしぐさ情報をロボットのしぐさパターンとして記憶する記憶手段と、前記ユーザ情報入力手段に入力された情報に基づいて前記パターンを再生する再生手段とを備え、前記記憶手段は、ユーザが特定の認識物を手に持つか足や頭に着用することにより、前記認識物を手足などとして検出し、ユーザのしぐさを認識、記憶することを特徴とする。

【0006】

【発明の実施の形態】以下、本発明の実施の形態を図面に基づいて説明する。図 1 は、本発明のロボットにおける触覚表現システムの 1 実施形態を示す制御系の全体構成図、図 2 は図 1 のユーザ・環境情報認識装置の制御系の構成図、図 3 は図 1 の行動選択決定装置の制御系の構成図である。なお、本発明においてロボットとは、マシン以外に、コンピュータ画面上で表現される電子ロボットを含むものである。

【0007】図 1 において、ロボット 1 は、外部情報入力手段 2、内部情報入力装置 3、制御装置 4、人工感情表現手段 5 を備え、外部情報入力手段 2 は、ユーザ 6 に関連する各種の外部情報を取り込み、制御装置 4 は、得られた内部情報および外部情報に基づいてロボットの行動を決定し、人工感情表現手段 5 によりユーザ 6 にロボットの感情や行動を伝達するようにしている。

【0008】外部情報入力手段 2 は、視覚的情報入力装置として、ユーザの顔、ジェスチャー、位置等を検出するカメラ 2 a、周囲の障害物を検出する IR（赤外線）センサ 2 b を備え、また聴覚的情報入力装置としてユーザ等の音、声を検出するマイク 2 c を備え、さらに触覚的情報入力装置として、ユーザの撫でや叩きを検出する感圧センサ 2 d、ロボットの脚や手の力・トルクを検出するトルクセンサ、ロボットの脚や手の関節位置を検出するポテンショセンサ 4 f を備えている。内部情報入力装置 3 は、ロボットの飢えの情報を検出するバッテリー残量計 3 a とロボットの疲れの情報を検出するモータ温度計 3 b を備えている。

【0009】制御装置 4 には、カメラ 2 a の信号によりユーザの顔情報を検出する顔情報検出装置 4 a およびジェスチャー情報検出装置 4 b、マイク 2 c の信号によりユーザの音声情報を検出する音声情報検出装置 4 c、感圧センサ 2 d の信号によりユーザとの接触情報を検出する接触情報検出装置 4 d、カメラ 2 a、IR センサ 2 b、マイク 2 c、感圧センサ 2 d の信号により周辺環境を検出する周辺環境検出装置 4 e、トルクセンサ 2 e、ポテンショセンサ 2 f の信号によりロボットの腕等の姿勢動作、抵抗力を検出する動作検出装置 4 f が備えられ、これらの情報は、ユーザ・環境情報認識装置 4 i に送られる。また、バッテリー残量計 3 a およびモータ温度計 3 b の信号は、内部情報認識処理装置 4 g に送られ、

ここでロボットの内部情報が認識される。

【0010】図 2 に示すように、ユーザ・環境情報認識装置 4 i においては、表情検出部 4 a と音声検出部 4 c で検出された情報が人特定部 7 に入力されここでユーザが特定される。また、腕など姿勢動作検出部 4 f、表情検出部 4 a で検出された情報および人の特定部 7 の情報に基づいて識別部 8 でユーザの状態が識別され、この情報は擬似感情生成部 4 j に送られる。また、音声検出部 4 c、ジェスチャー検出部 4 b、なで・たたき検出部 4 d で検出された情報および人の特定部 7 の情報に基づいて受け付け部 9 でユーザからの情報が入力され、この情報は特徴行為記憶部 4 m に送られる。また、周辺環境検出部 4 e で検出された情報は環境認識部 10 に送られ、この情報は行動決定手段 4 k に送られる。

【0011】ユーザ・環境情報認識装置 4 i におけるユーザの状態識別部 8 の情報は、擬似感情生成装置 4 j に送られ、ここで、記憶情報処理装置 4 h に記憶された感情モデルに従ってロボットの擬似感情（人工感情）が生成される。ここで感情モデルは、ロボットの感情を表す怒り、悲しみ、喜び、恐れ、嫌悪、疲れ、飢え、眠気等のパラメータを求めるための計算式であり、音や画像で検出したユーザ情報（ユーザのご機嫌度、命令など）および環境情報（部屋の明るさや音等）に応じてロボットの感情が生成される。例えば、ユーザが帰宅したときは、ロボットは「喜び」の感情を表現し、他人が入ってきた場合には「怒り」の感情を表現する。このとき、ユーザの誉めたり、叱る行為により、ロボットの感情を変化させロボットを成長させていく。また、ロボットが赤ん坊の頃は幼稚な動きをするように反応し、成長するにつれて大人の動きをするように感情モデルを作成しておく。このようにして成長していくロボットの性格、行動は情報記憶処理装置 4 h に記憶され、学習処理を行う。

【0012】ユーザ・環境情報検出装置 4 i と擬似感情生成装置 4 j の情報は、特徴的行為記憶処理装置 4 m に送られ、ここで、ロボットがユーザに徐々に近づいていく行動とか、ユーザのしぐさを学習するとかの特徴的行為を記憶、処理する。ユーザ・環境情報認識装置 4 i、擬似感情生成装置 4 j および特徴行為記憶処理装置 4 m の情報は、行動選択決定装置 4 k に送られる。

【0013】図 3 は行動決定手段（行動選択決定装置）4 k の制御系の構成図であり、擬似感情生成部 4 j の情報は、行動セット選択部 11 に送られ、ここで記憶情報処理装置 4 h に記憶された行動セット（行動ライブラリ）を参照してロボットの基本行動が決定され、行動セットパラメータ設定部 12 に送られる。行動ライブラリは、ロボットが特定の表現をするための動作シーケンスであり、例えば、行動パターンが「前進」の場合には、「所定の順序で各脚から動かす」というシーケンスであり、行動パターンが「おどり」の場合には、「後脚をたんで座姿になり、前脚を交互に上げ下げする」という

シーケンスであり、また手を上げる、下げる、前に出すなどの基本行動パターンが記憶されている。特徴行為記憶部 4 m で記憶した行動セットの内容は、行動再現部 1 3 に送られ、ここで行動セット選択部 1 1 の行動セットを補正し、行動セットパラメータ設定部 1 2 に送られる。行動セットパラメータ設定部 1 2 においては、例えばロボットがユーザの方向に近づく速度やユーザの手を掴む抵抗力などが設定され、これらの情報は行動実行部 5 に送られる。

【0014】行動選択決定装置 4 k において決定された情報は、人工感情表現手段（行動実行部）5 に送られ、視覚的感情表現装置 5 a においてはロボットの顔や腕、体等の動作機構が駆動され、アテンション（注意）やロコモーション（運動）情報（例えば顔の表情、首振り、おどり）としてユーザ 6 に伝達され、聴覚的感情表現装置 5 b においてはスピーカが駆動され、音程、リズム情報（例えば鳴き声）としてユーザ 6 に伝達され、触覚的感情表現装置 5 c においては顔や腕、体等の動作機構が駆動され、抵抗力、リズム情報（例えば「お手」をしたときのユーザが受ける触覚）としてユーザ 6 に伝達される。なお、顔や腕、足、体等のロボット構成部の動作機構は、モータ、電磁ソレノイド、エアまたは油圧シリンダなどのアクチュエータを備える。

【0015】本発明において特徴とすることは、特徴的行為記憶処理装置 4 m において、ユーザ・環境情報検出装置 4 i と擬似感情生成装置 4 j の情報に基づいて特徴的行為を作成し、この情報を行動選択決定装置 4 k に送りロボットに特徴的行為を行わせることである。これを図 4～図 7 により説明する。

【0016】図 4～図 7 は、本発明のロボットにおける自律的行動表現システムの 1 実施形態を示し、図 4 はしぐさ記憶の処理を示すフロー図、図 5 は、図 4 の処理を説明するための図、図 6 はしぐさ再生の処理を示すフロー図、図 7 は図 6 の具体例を説明するための図である。なお、以下の説明では、ロボットの自律的行動を「しぐさ」として説明する。

【0017】図 4 は、しぐさ記憶の処理を示し、先ず、ステップ S 1 で部屋の明るさ、時刻等の環境情報を読み込み、ステップ S 2 でロボットの感情を表す怒り、悲しみ、喜び、恐れ、嫌悪、疲れ、飢え、眠気等の感情状態を読み込み、ステップ S 3 でユーザの認識を行う。次にステップ S 4 でしぐさ記憶を実行するための開始トリガの有るか否かを判定する。開始トリガの例としては、ユーザがスイッチを押す行動や、「覚えて！」というような指示音声等の特定の行動、或いはロボットの感情である「喜び」レベル（「喜び」以外の感情状態でもよい）が所定値以上かつユーザが正面にきたとき、常にユーザのしぐさの履歴を一時記憶にとっておき、直前の動作を繰り返してユーザが喜んだ等の場合などが挙げられる。開始トリガがなければそのまま処理を終了する。

【0018】ステップ S 4 で開始トリガが有る場合には、ステップ S 5 で、図 5 に示すように、ユーザの体幹 B と腕 R、L の画像を抽出し、ステップ S 6 で右腕 R、左腕 L の動きの位置を時間 t にしたがって記録する。これは、抽出画像を 1～4 に水平分割し、例えば右腕 R であればその位置が 4、3、2、3… … というように記録する。なお、ステップ 5 の方法によらず、ユーザがロボットにしぐさを直接教えるようにしてもよい。この処理はステップ S 7 で終了トリガがあるまで続けられる。終了トリガの例としては、ユーザがスイッチを押す行動や、「お終い」というような指示音声等の特定の行動、或いは開始から一定の時間が経過したとき、ユーザが一定時間以上同じ姿勢のままのときなどが挙げられる。終了トリガが有った場合には、ステップ S 8 で今回記録したパターンと従来記憶されたパターンとが比較され、新しいパターンの場合にはステップ S 9 で新パターンを、ステップ S 1～S 3 のユーザ情報、環境情報および感情状態とセットにして記憶する。

【0019】図 6 は、しぐさ再生の処理を示し、先ず、ステップ S 1 で部屋の明るさ、環境音、時刻等の環境情報を読み込み、ステップ S 2 でロボットの感情を表す怒り、悲しみ、喜び、恐れ、嫌悪、疲れ、飢え、眠気等の感情状態を読み込み、ステップ S 3 でユーザの認識を行う。次にステップ S 4 でしぐさ再生を実行するための開始トリガの有るか否かを判定する。開始トリガの例としては、ユーザがスイッチを押す行動や、或いはロボットの感情である「喜び」レベルが所定値以上かつ同一ユーザがいるなどである。開始トリガがなければそのまま処理を終了する。

【0020】ステップ S 4 で開始トリガが有る場合には、ステップ S 5 で、しぐさのパターンを選択し、ステップ S 6 で記憶したシーケンスに沿って手を上げる、下げるなどの基本行動パターンを選択して順次実行する。なお、基本行動パターンは記憶したパターンの軌跡に最も近いものを選択し、また組み合わせる。この基本行動パターンは、当初は大きく簡単な動きであるが、時間経過、ユーザの操作回数などが一定値以上になると、各行動パターンを分割して細分化し、徐々に複雑な動作ができるようにすることも可能である。パターンの選択方法としては、ランダムに選択する方法、記憶した感情状態、時刻に近いものを選択する方法、同一ユーザが前にいるときのものを選択する方法などがある。図 7 は、図 6 のパターン選択を説明するための図である。ユーザ毎、朝、昼、夜毎、喜びの度合いに応じてパターン①～③がマップとして記憶されている。

【0021】次に、本発明のロボットにおける自律的行動表現システムの他の実施形態について説明する。上記実施形態においては、ユーザの手の動きなどをジェスチャとして認識・記憶し、ロボットの自律的行動として表出することによって、ユーザとのインタラクションを感

じさせるようなシステムを提案している。しかしながら、画像処理などによってユーザの位置や姿勢を検出し、両手などの位置を抽出しているため、計算負荷が膨大になり安価なマイコンなどで実現することは困難である。

【0022】そこで、本実施形態においては、ユーザがロボットの手を上げ下げするなどして遊んだときにその動かし方を記憶し、ロボットの自律的行動として表出することによって、ユーザとのインタラクションを感じさせるような制御を行うシステムにおいて、ユーザが特定の認識物を手に持つか足や頭に着用することにより、前記認識物を手足などとして検出し、ユーザのしぐさを認識・記憶しやすくすることを特徴としている。

【0023】前記特定の認識物としては、特定の色の付いたマーカ、特定の光、電波、音波を発信する発振器、特定の光などを反射するマーカなどであり、常にロボットに正対するような形状または正対するように保持できる形状からなっている。

【0024】以下に、具体的な実施例について説明する。ロボットには予め手を上げる・下げる・前に出すなどの基本行動パターンを組み込んでおく。ユーザが動かしたとき、その基本行動パターンの中から動かした軌跡に最も近くなるものを選択し、組み合わせで行動シーケンスを作り記憶する。基本行動パターンは、当初は大きく簡単な動きであるが、時間の経過・ユーザの操作回数などが一定以上になると、角行動パターンを途中で分割して細分化し、しだいに複雑な動作ができるようにする。しぐさを記憶し始めるトリガは上記実施形態と同様である。

【0025】ロボットに動きを見せる際に、例えば、右手に赤、左手に緑の手袋をはめてロボットに正対する。ロボットはカメラより入力された画像の中から視野内の赤色の領域と緑色の領域を抽出し、これらを右腕、左腕として認識し、その動きの位置を時間に従って記録する。記録方法は上記実施形態と同様である。

【0026】カメラは固定である必要はなく、例えば手の動きを追従するように動かすことができる。その場合、動きの記録は視野内における座標とカメラアングル

を併記するか、または合成した座標値を記録する。

【0027】検出の対象として、上記の例では手袋を使用しているが、例えば異なる周期で点滅するランプを装着したり、反射材を装着してロボットがそれをランプで照射するようにして、それをカメラで検出するようにしてもよい。

【0028】また、ジェスチャの検出手段はカメラでなくとも、例えば、手に超音波の発振器を装着し、ロボットに受信器を搭載して音波の位置を計測することによって動きを認識するようにしてもよい。さらに、これらのマーカなどは手や腕に限らず、頭や足にも装着することが可能であり、その場合には全身の動きを認識し、まねをすることも可能である。

【0029】

【発明の効果】以上の説明から明らかなように、本発明によれば、ユーザがロボットと遊ぶときに、腕などを動かしたパターンや、ロボットの前でユーザがとった行動などを、後でロボットが自律的に再現して見せることにより、ユーザとロボットとの間で親近感が増し、ユーザに飽きられることのないロボットを提供することができる。とくに、請求項11～15記載の発明によれば、画像処理による計算負荷を低減することができ安価なマイコンなどで実現することができる。

【図面の簡単な説明】

【図1】本発明のロボットにおける自律的行動表現システムの1実施形態を示す全体構成図である。

【図2】図1のユーザ・環境情報認識装置の制御系の構成図である。

【図3】図1の行動選択決定装置の制御系の構成図である。

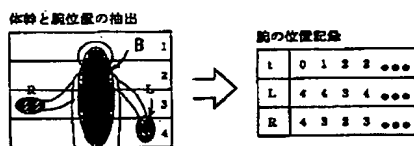
【図4】本発明のロボットにおける自律的行動表現システムの1実施形態を示し、しぐさ記憶の処理を示すフロー図である。

【図5】図4の処理を説明するための図である。

【図6】図4で記憶したしぐさを再生するための処理を示すフロー図である。

【図7】図6の具体例を説明するための図である。

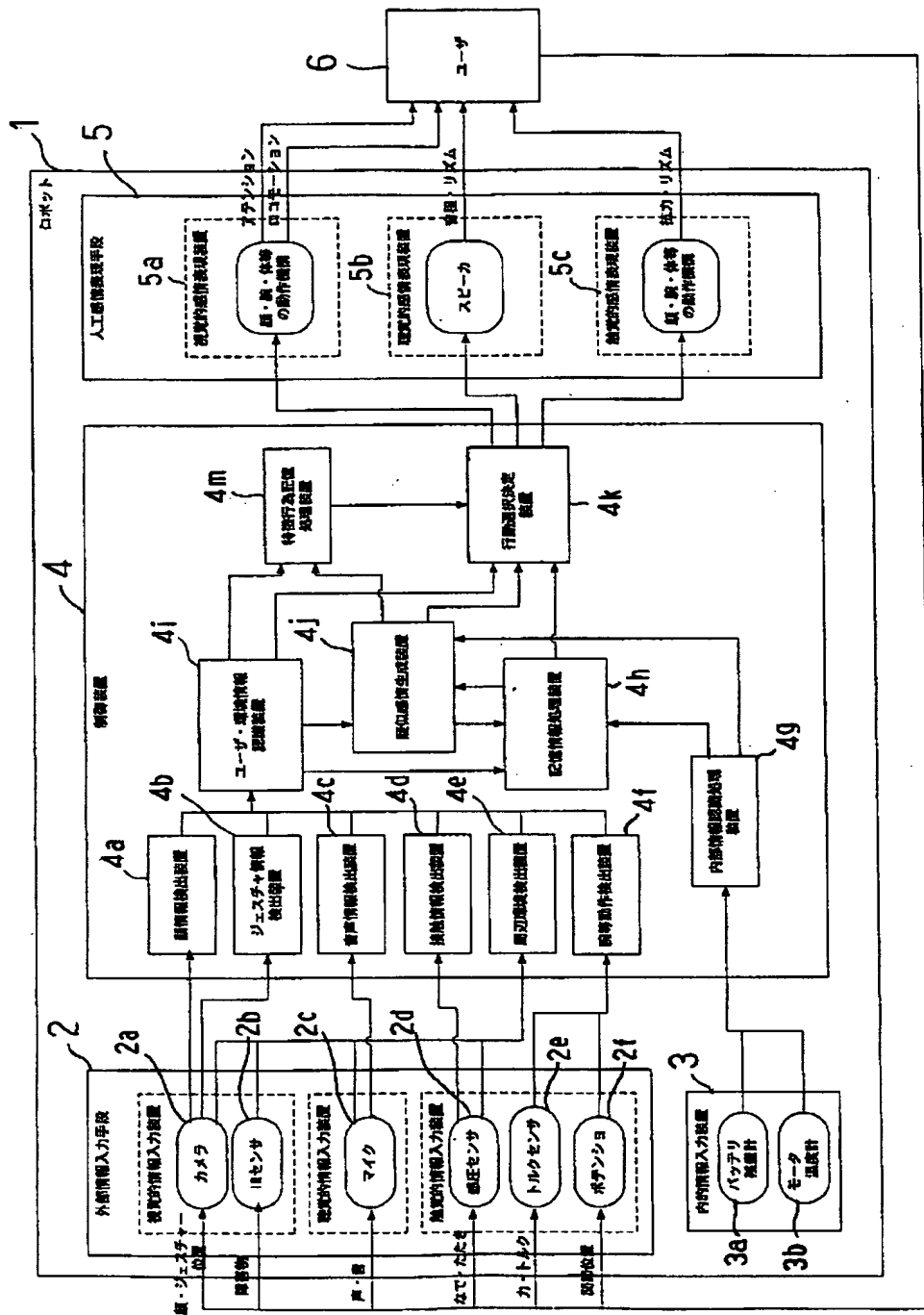
【図5】



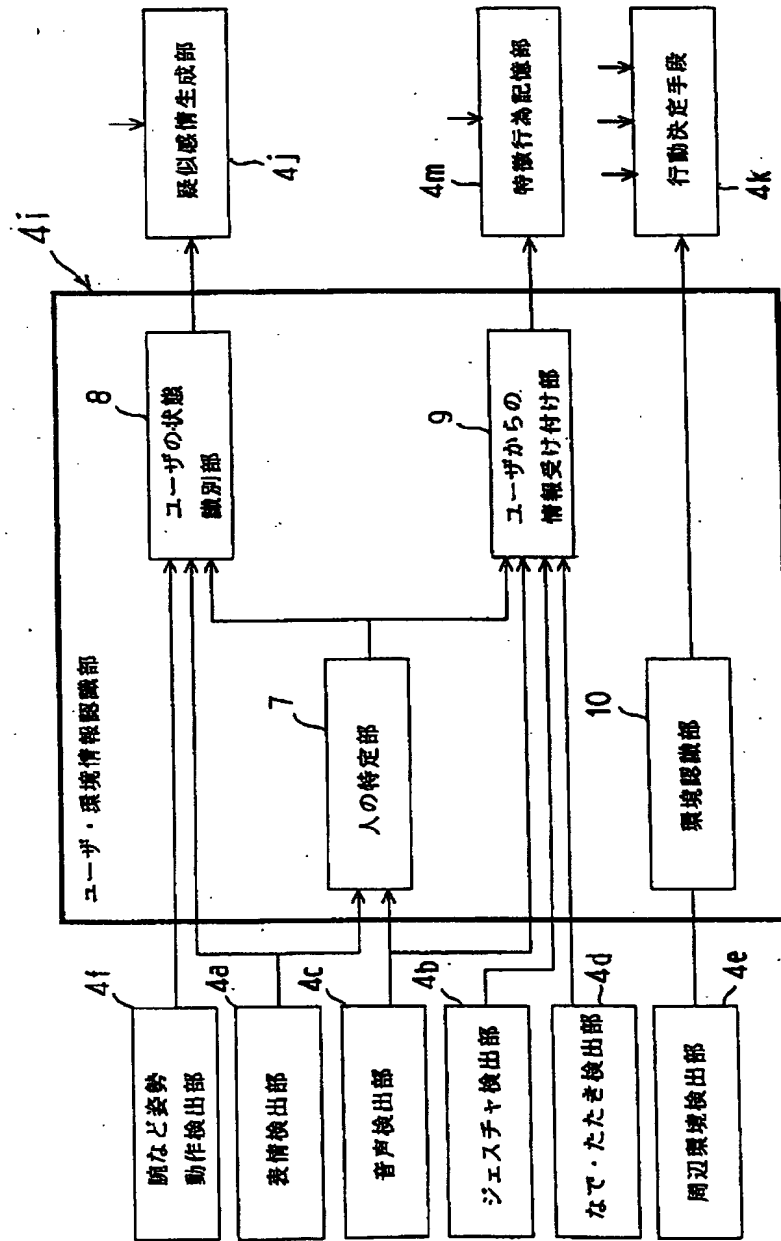
【図7】

| ユーザ2 |    |      |      |     |
|------|----|------|------|-----|
| ユーザ1 |    |      |      |     |
| 時    | 喜び | 0.5～ | 0.7～ | 0.9 |
| 朝    | ①  | ①    | ②    |     |
| 昼    | ②  | ③    | ③    |     |
| 夜    | ①  | ②    | ③    |     |

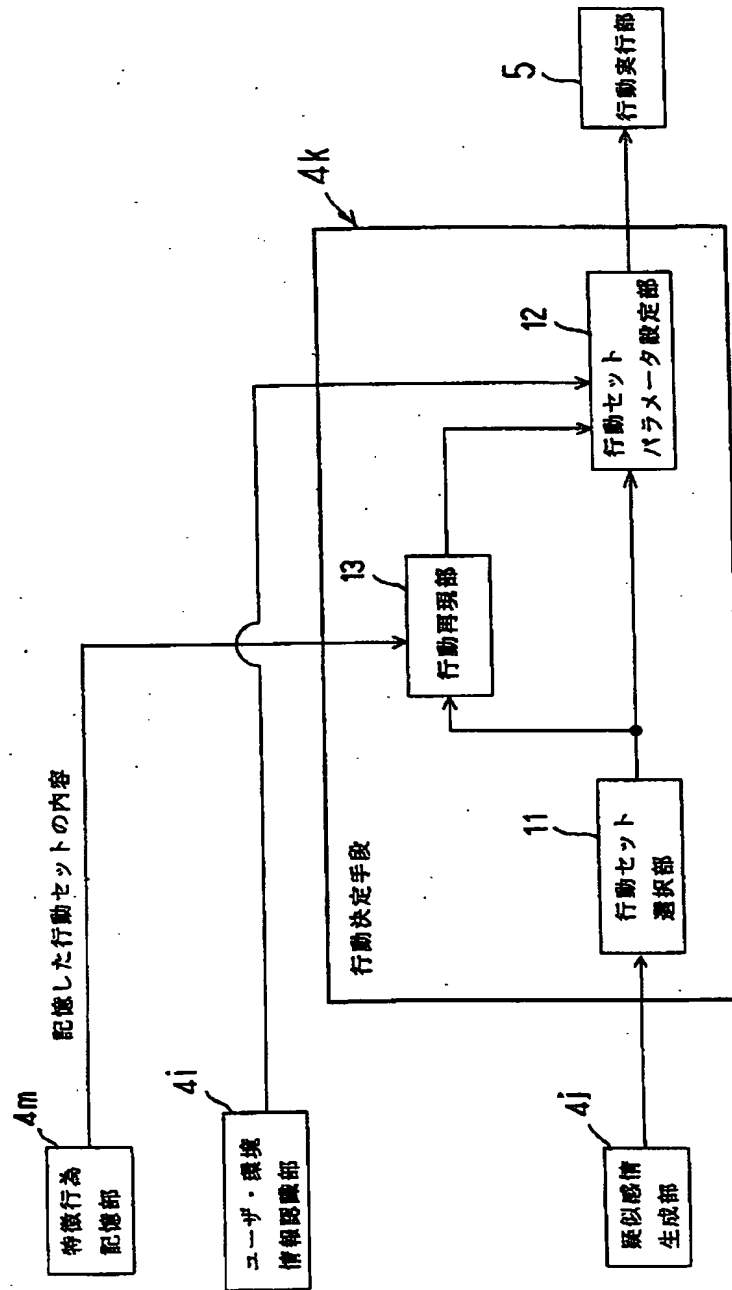
【図1】



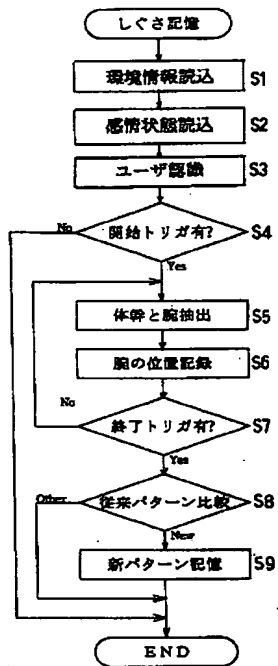
【図2】



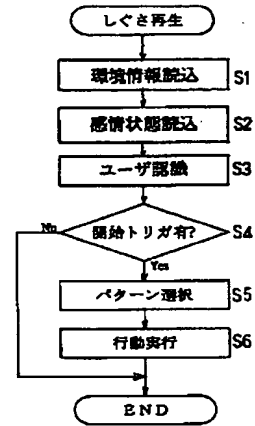
【図3】



【図4】



【図6】



フロントページの続き

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